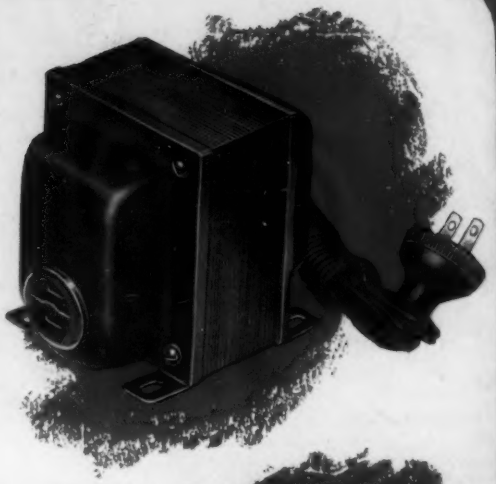
# for LINE VOLTAGE CONTROL

STEPDOWN • • • ADJUSTMENT • • • ISOLATION • • •

## STEPDOWN AUTO TRANSFORMERS



To reduce line voltage of 200-240 volts, 50-60 cycles, to 100-120 volts 50-60 cycles for operating radios, amplifiers, appliances, etc. Will safely handle any device consuming wattage up to the ratings shown. With six foot cord and female receptacle.

| Type No. | Application | Wgt. Lbs. | List Price |
|---|---|---|---|
| R-41 | 85 watt capacity | 4 | $7.50 |
| R-42 | 125 watt capacity | 5 | 8.50 |
| R-43 | 175 watt capacity | 5½ | 9.50 |
| R-44 | 250 watt capacity | 6½ | 12.50 |
| R-45 | 500 watt capacity | 12 | 20.00 |
| R-46 | 1200 watt capacity | 18 | 35.00 |
| R-64 | 2500 watts (no cord) | 30 | 70.00 |

## LINE VOLTAGE ADJUSTERS

*with meter*

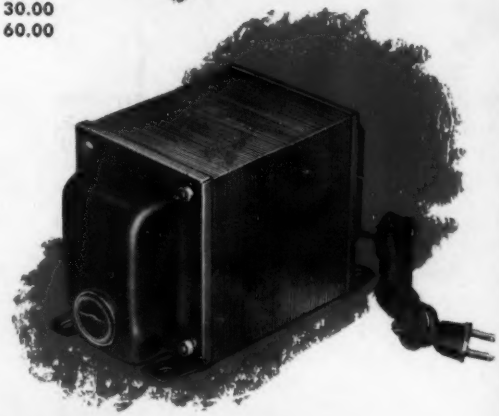
The perfect answer to abnormal or fluctuating line voltage. Adjust switch so that meter reads at red line and you know that your equipment is working at correct voltage.

These units combine a tapped auto-transformer with a switch and meter in a compact, rugged assembly.

The nine tap switch provides for line voltages of 60 to 140 volts on 115 volt output models and 160 to 240 volts on 230 volt output models. All units are designed for 50/60 cycle service and come complete with 6 foot input cord and plug and outlet receptacle.

| Type No. | Primary Voltages | Sec. Volts | Watts | Wgt. Lbs. | List Price |
|---|---|---|---|---|---|
| R-78 | 60,70,80,90,100,110,120,130,140 | 115 | 150 | 6 | $18.00 |
| R-79 | 60,70,80,90,100,110,120,130,140 | 115 | 300 | 9 | 22.00 |
| R-80 | 60,70,80,90,100,110,120,130,140 | 115 | 600 | 13 | 30.00 |
| R-81 | 60,70,80,90,100,110,120,130,140 | 115 | 1200 | 21 | 60.00 |
| R-83 | 160,170,180,190,200,210,220,230,240 | 230 | 150 | 6 | 18.00 |
| R-84 | 160,170,180,190,200,210,220,230,240 | 230 | 300 | 9 | 22.00 |
| R-85 | 160,170,180,190,200,210,220,230,240 | 230 | 600 | 13 | 30.00 |
| R-86 | 160,170,180,190,200,210,220,230,240 | 230 | 1200 | 21 | 60.00 |

## ISOLATION TRANSFORMERS



Ideal for isolating line noise, test equipment, AC-DC sets, etc. Excellent electrostatic shielding. 2000 volt breakdown test. With six foot cord and female receptacle. Primary 110-120 volts, 50/60 cycles—Secondary 110-120 volts.

| Type No. | Rating | Wgt. Lbs. | List Price |
|---|---|---|---|
| R-73 | 100 watts | 6 | $13.00 |
| R-74 | 250 watts | 12 | 24.00 |
| R-75 | 600 watts | 20 | 35.00 |
| R-76 | 1200 watts | 30 | 55.00 |
| R-77 | 2500 watts (no cord) | 70 | 95.00 |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A complete line, including Air Core I. Fs.
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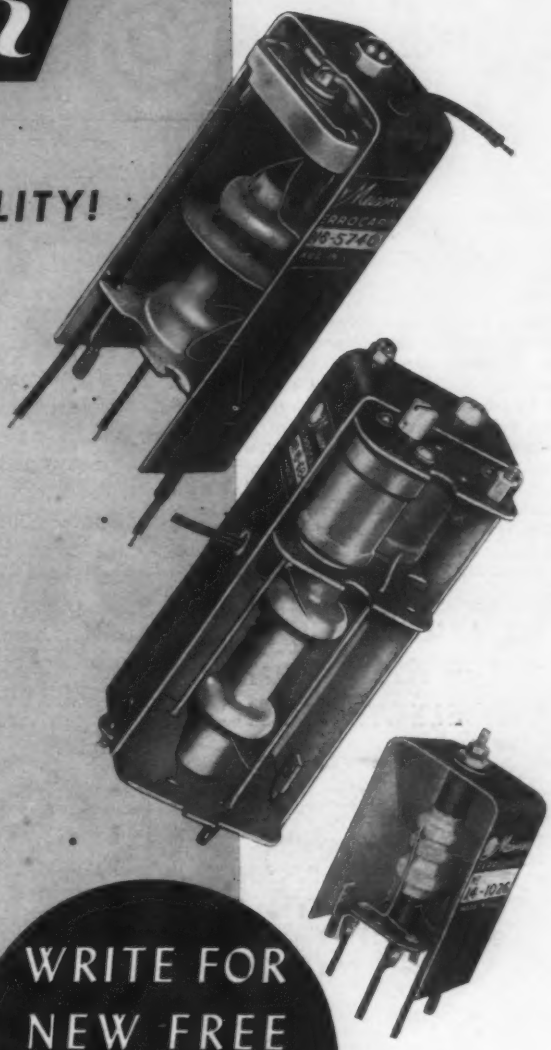

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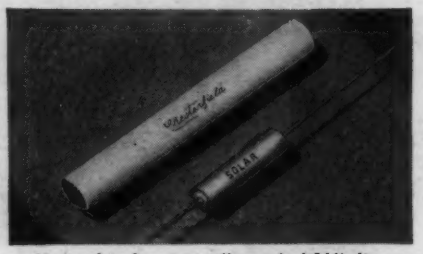
The Solar System
electronics edition • July 1947

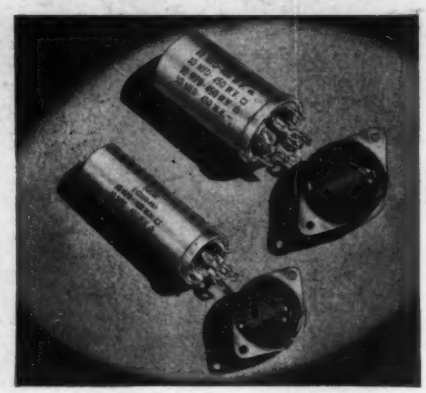
MINIATURE FOIL PAPER METAL TUBULAR FOR TIGHT PLACES



Housed in hermetically-sealed ¼" diameter metal tubes, Solar Type QA capacitors are of ultra-compact multi-paper and foil construction. They are useful in a wide variety of applications from hearing aids to firing devices. Capacitances up to .01 mf at voltage ratings up to 600 wvdc are standard.

Mineral oil impregnated units are available as Types QAGM and QAIM with grounded and insulated sections, respectively. Halowax units may be had by specifying Types QAGH and QAIH for grounded and insulated windings, respectively.

NEW MOUNTING BASE ON "TWIST-PRONG" DRY ELECTROLYTICS



Introduction of a new heavy Bakelite-rubber mounting base on Solar Type DY "twist-prong" dry electrolytic capacitors gives these units a more rigid base assembly than the molded rubber base formerly used.

This new design permits use of Type DY units as plug-in capacitors by using the new capacitor mounting sockets recently placed on the market. To do this simply cut off the blank mounting tab on each capacitor.

All terminals are clearly identified on each base and the code markings are stamped on the capacitor container.

SOLAR MANUFACTURING CORPORATION
"QUALITY ABOVE ALL"
285 MADISON AVENUE
NEW YORK 17, N. Y.

# BUSINESS BRIEFS

By W. W. MacDONALD

**The Parts Show** in Chicago afforded an excellent opportunity to check on the state of business, since exhibitors making components of necessity have their finger on its pulse.

Business is of course off from the abnormal wartime peak and, generally speaking, is probably going off more. Actual consumer need is high, however, despite resistance occasioned by high prices, so the expected bump should not be deep and should not last long as such bumps go.

The market is spotty, some manufacturers exhibiting concern while others appear to be feeling pretty good about prospects. The answer, which may explain why some economists are crying the blues while others are optimistic, is the simple fact that for *some* people, in *some* branches of the field, business is bad, while for other people, in other or even the same branches, business is good. It is hard to generalize and be right.

**Speaking Of The Show,** attendance was excellent, particularly with respect to quality. Exhibits contained many interesting new products, with only a modicum of fruit-juicers and can-openers.

**Printed Circuits** are moving rapidly out of the experimental stage. At least two radio set makers will be using Centralab interstage audio couplers involving the principle by fall, television receiver sub-assemblies using the scheme are likely to be seen, and one manufacturer is known to be planning an extremely small personal radio almost entirely devoid of conventional wiring and components.

**Transmitter Designers** take note: Fred Lack of Western Electric, speaking at a recent meeting of an RMA engineering section, said that all the signs point toward a greatly expanded transmitter market, but that while there will be many more customers in the future most of them will have less money to spend.

The key to new markets may lie more in the engineer's ability to design equipment that does a satisfactory job at low cost than in his ability to turn out gear embodying expensive refinements.

**Price May Be King** for awhile in the home radio receiver market. That's the way it looks at this writing. • Fortunately, it is possible to make a radio do a lot of things it should do at low cost if the designer exercises his ingenuity in that direction. The receiver described on p 80 of this issue is a good example.

**Many A Truth** is spoken in jest. Rueful laughter greeted the recent remark of a prominent industry leader at a technical meeting to the effect that too many managements in the radio business hire engineers for the mere purpose of adapting new RCA and Hazeltine Lab circuits to production and sales requirements.

**Receiver Manufacturers** licensed by RCA total 154. Hazeltine has 130 on the books.

**Wire Recordings** can be duplicated in quantities, much like movie films. At least one company is known to be experimenting, with the object of developing a system which will permit many copies to be made simultaneously from one matter. If it works out economically, and it looks as if it would, wire will ultimately be much more competitive with disks.

**Induction Heating** applications have sometimes dictated the use of tube-generated r-f and sometimes called for power generated at a lower frequency by rotating machines. Each method has had its field. Now we hear that there may be a wedding between the two. It seems that certain applications, such as the surface-hardening of

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# TUNED-RIBBON

## reproducers

**MUSICALLY** . . . *The Tuned-Ribbon message in a few words . . .*

***"Startlingly Realistic"***

**One of the many superlatives used by Electronic Industries magazine* in an editorial describing this new development.**

**It brings to reproduced music something that was not there before.**

**TECHNICALLY** . . . *The Tuned-Ribbon Reproducer actually meets the long sought for theoretical ideal of* —

- **Near-zero mass**
- **Linear response to 15 k.c.**
- **Practical output** (about — 30 db)
- **Point Pressure 14 grams**
- **Jewel point**
- **NO torsional action**

**TUNED-RIBBON Pickup model *STUDIO-81***
***(actual size — special arm not shown)***

- **A model for every purpose**

**Send for complimentary reprint of this editorial*

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**500 Fifth Avenue New York 18**

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# special devices

such as fishing reels, timing devices, control motors, etc. often require small gears with specially designed teeth.

Beaver Gear engineers are trained to assist you in the design and application of these gears. In our modern plant, craftsmen — with many year's experience in manufacturing gears — work with the latest type of equipment to assure you of receiving gears machined precisely to your specifications.

We invite you to submit your prints for quotation without obligation.

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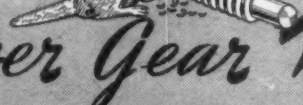
Describes Beaver Gear's facilities and methods; also includes table of gear tooth parts.



Beaver Gear Works Inc.

1021 PARMELE STREET, ROCKFORD, ILLINOIS



gears, might be handled more economically by preheating with a low frequency and then switching to r-f.

**Television Receivers** bearing nationally-known trademarks are not necessarily made by the companies whose names they bear. Some are bought from other manufacturers, much as private-brand radios are contracted for.

In the initial stages of the business at least, it is likely that this practice will be widespread. There are a number of advantages, not the least of them being the fact that buying rather than building ducks the very considerable investment in engineering, production, and testing apparatus that would otherwise be necessary.

**Cathode Ray Tubes** for television represent a possible bottleneck in the rapid development of the art, so much so that engineers from competitive companies are finding the welcome-mat out at RCA's Lancaster plant, where a semi-automatic c-r tube production line is in operation. Copying of the mass-production technique is thus encouraged. For awhile at least there should be more than enough business for all.

**Receiving Tube Production** was, as predicted back in February, substantially in balance with demand in the Spring. Now the pendulum has swung the other way and there is an oversupply of most types. Reason is twofold; wartime increase in tube production capacity and consumer resistance to high-priced radios.

**About 1,000 Models** are turned out by radio receiver manufacturers in the average year, regardless of how many manufacturers there are in the field, according to Howard Sams of Photofact Service. He ought to know, since his organization must be set up to check the circuit of each new set, and has done a lot of research on the subject.

Incidentally, Howard says that few sets that find their way into the field have precisely the circuit,

or precisely the components, that manufacturers' circuit diagrams say they have.

**Electronic Navigation Aids** such as loran are attracting considerable attention among geophysical people. Companies searching for oil, particularly, need some method of marking the spot where the body is buried, especially if it happens to be buried beneath the sea. Electronic equipment developed during the war seems ideal for the purpose. More about it in our feature pages soon.

**Aviation Communications** on 121.5 mc are temporarily stymied by lack of equipment. We understand that vhf gear suitable for use in aircraft is now beginning to come off production lines, however, and that the bottleneck will probably be broken before winter.

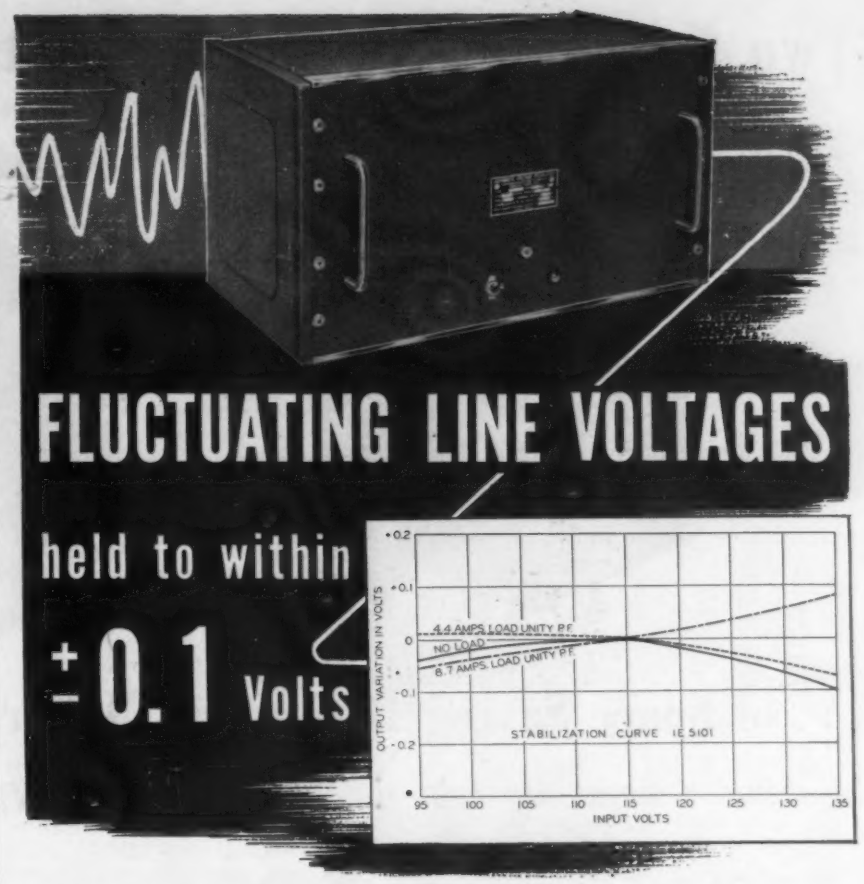
**Instrument Landing Systems** used by the AAF during the war totalled roughly 200. Some 50 of them have been relocated at Airforce Fields in the United States.

**Latin American Countries** will purchase approximately $17,000,000 worth of American radio receivers in 1947, according to the Department of Commerce.

**We Understand** that South Americans have developed a distinct aversion to surplus goods, won't touch it with a 10-foot pole. IRC's Harry Ehle, who has just returned from a tropical business trip, says they have been burned by all sorts of trick merchandise and are now twice-cautious.

**We Hear That** the IRE will rent Grand Central Palace in New York again next year, from March 17 to 30 if those dates are open. More in our "News of the Industry" department if and when it becomes official.

**Story Of The Month** is the one about the manufacturer that ducked a patent by turning out a cheap timer for hotel quarter-in-the-slot radios. Slick bellboys discovered a way to turn them on with a nailfile, sold this technical information to guests for 15¢.


# STABILINE *Instantaneous Electronic* VOLTAGE REGULATOR

With a STABILINE type IE Voltage Regulator in the power line, electrical apparatus is assured of constant voltage. Regardless of line changes — rapid fluctuations or slow variations — the delivered voltage is held to within ± 0.1 volts of the preset value. Typical are the performance curves of type IE5101. Although the input line voltage may vary from 95 to 135 volts, the preset output voltage is stabilized to well within ± 0.1 volts.

Fluctuating line voltage is just one problem of many in maintaining constant voltage. Others are varying frequencies, loads, power factors together with waveform distortion. An investigation of the STABILINE type IE will show, in addition to stabilization of ± 0.1 volts, such characteristics as . . . waveform distortion never exceeding 3 percent . . . regulation to within ± 0.15 volts for any load current change or load power factor change from lagging .5 to leading .9.

***Write Superior Electric, 887 Laurel Street, For Information and Literature***

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**Powerstat Variable Transformers • Voltbox A C Power Supply • Stabiline Voltage Regulators.**

# CROSS TALK

►**MIXED** . . . Our feelings were mixed indeed when we received in the same month two announcements from the same manufacturer of measuring equipment. One praised a newly-offered device because it did not use any vacuum tubes or other components having limited life. The other stated that another device was available having a tube conservatively operated for long life. Take your choice, limited life or long life. Both available.

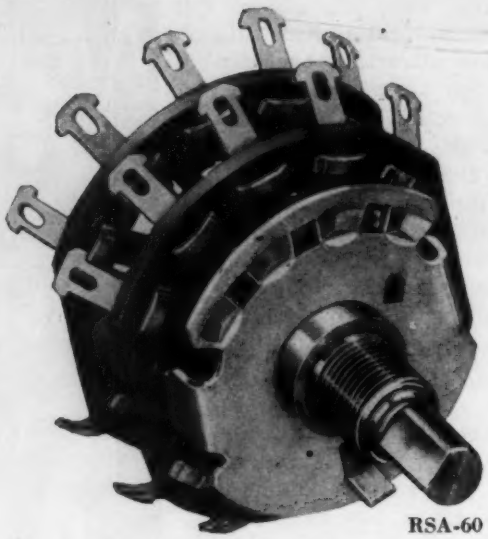
This confusion points up a recurring problem in industrial uses of tubes. Tube life is still a bugaboo; it still scares too many customers who should know better. Long-life tubes are available, and conservative designs are well understood and widely employed. Tubes are used, by and large, only when they serve a purpose not otherwise obtainable with equal ease or economy. If the design is right, the device may be used without concern about tube life. If it's not right, don't buy it.

►**PRIVILEGE** . . . Since May first last, owners of television sets served by the Norwich, Connecticut, municipal power plant have been required to pay $1.26 net extra on their electricity bill each month, not for juice (which is charged for as usual), but for the privilege of having a set connected to the system. This is, as yet, a minuscule threat to the television industry, but it is a prime example of how misinformation can get worked into the rate schedule of a public utility. The extra charge was worked out by a reputable firm of consulting engineers on the following thesis: A television set requires about five times as much power as the average radio set. It is used primarily at night. When an outstanding program is available, all the video sets are turned on, and the demand on the electric system goes up, at a time when the lighting load is already high. So extra load capacity must be provided to take care of the television sets. This capacity costs money and must be paid for, preferably by the television set owner. So far, the argument makes some sense, or will when everyone in Norwich has a television receiver and gangs up on the power company all at once, an event several years away by any count. But the large charge of $1.26 gives us cause to wonder how it was figured out. And our wonder is increased when we hear that a large part of the charge is for demand capacity taken by 500 to 1,000 watts of extra lighting which, the consultants claim, will be turned on *only* when the television set is working. This is certainly a new idea to members of the television audience, most of whom have been busy turning lights *off* before sitting down for television entertainment. The consulting firm claims that the new television sets will have pictures so bright that the viewer cannot stand to view them without brightening up the room some 500 to 1,000 watts worth. Whew! The new picture tubes are bright all right, but they are operated at peak brightness only when sunlight streams in the windows and it is inconvenient to draw the shades. At night, the televiewer adjusts the brightness control to suit the normal room illumination. True, he doesn't have to turn off any lights. But, by all that's holy, he doesn't have to turn any *on*. Viewers in Norwich are advised to look for real estate across the town line. Or better yet, invite the power company manager in to see the ball game (night game, that is).

►**AD** . . . A 50-kw broadcast station recently advertised in a Boston paper that it was "New England's Most Powerful Station", basing this claim on its allocation to a low-frequency channel. The ad goes on to explain, "The lower the position on the dial, the more power per watt." We wonder whether the power companies know about this. A 60-cycle watt, by this rule, ought to be a pretty powerful hunk, and ought to cost more in proportion. But a watt's a watt for all that, whether wiggling fast or slow. The slow ones just last a little longer, especially over the rocky soil of the Pilgrim fathers.

# Two New Single or Double Section Switches . . .

RSA-50



RSA-60

## . . . of Space Saving Design and Mallory Precision Quality

### . . . *Yet They Cost No More!*

Where space is a factor—dependability essential—*low cost a prerequisite*—the Mallory RSA-50 and RSA-60 switches fill the bill!

These *new* circuit selector switches, with section and terminal design identical to that of the famous Mallory RS-50 and RS-60 switches, are designed for band and tone control switching in radio receivers and other electronic applications where medium and low torque indexing action is desired.

The index assembly is of durable design and constructed with a minimum of parts—affording dependable service life with low torque and positive indexing action.

Note these many features, inherent in all the Mallory RS series, which contribute to the dependability and quality of these two new additions to the line:

- **Insulation of high-grade, low-loss laminated phenolic.**
- **Terminals and contacts of special Mallory spring alloy, heavily silver-plated to insure long life at low contact resistance.**
- **Terminals held securely by exclusive Mallory two-point fastening — heavy staples prevent loosening or twisting.**
- **Double wiping action on contacts with an inherent flexing feature—insures good electrical contact with the rotor shoes throughout rotation.**
- **Six rotor supports on the stator—insure accurate alignment.**
- **Brass rotor shoes, heavily silver-plated—insure low contact resistance.**
- **All shoes held flat and securely to phenolic rotor by rivets—prevents stubbing—insures smooth rotation—*minimum of noise in critical circuits.***

The RSA-50 and RSA-60 are both available in one or two section construction. The RSA-50 accommodates up to twelve terminals on either side of the section and provides from 2 to 6 positions. The RSA-60 accommodates up to ten terminals on either side of the section and provides from 2 to 5 positions. The RSA-60 has the narrow section design—ideal for under chassis mounting, where space saving is paramount.

**ENGINEERING DATA SHEET**

Send for the Mallory Engineering Data Sheet on the RSA-50 and RSA-60. It contains complete specifications for available circuit combinations with respective terminal locations, dimensional drawings—everything the engineer needs to adapt the RSA-50 or RSA-60 switch to a particular circuit.

**SPECIFICATION SHEETS**

Specification sheets for the RSA-50 and RSA-60 switches have also been prepared. These sheets are printed on thin paper to permit blueprinting. The sectional drawings indicate standard and optional dimensions—make it easy for you to order production samples built to your requirements.

P. R. MALLORY & CO. Inc.

**MALLORY SWITCHES**

**(ELECTRONIC, INDUSTRIAL and APPLIANCE)**

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

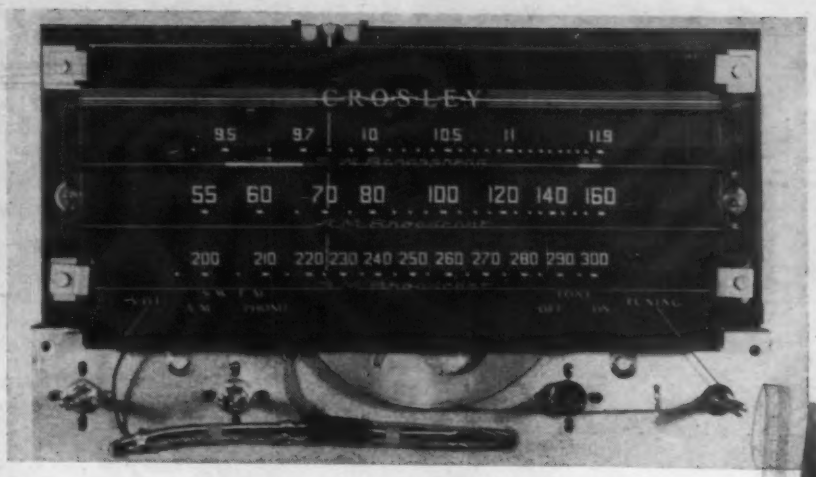



FIG. 2—Dial panel and chassis of the receiver

fidelity, since high selectivity was considered more essential for nighttime listening on the a-m services.

High selectivity is also achieved on the f-m band. Figure 6 shows the bandpass of the 10.7-mc intermediate frequency for f-m (a conventional single superheterodyne circuit is used for f-m). The humps of this curve, separated 150 kc, are positioned so they fall on the humps of the discriminator characteristic, the combination of the two curves producing a linear detection characteristic with steep skirts (Fig. 7). As a result, the gain of the i-f stages and the voltage output of the discriminator are higher than normal, and the selectivity is greater than can be achieved with the same components conventionally tuned. No limiter is used.

Low noise is achieved on all bands by cave in front-end design and is preserved by the use of a 6AC7 high-$g_m$ converter. On the f-m band, the input circuit is an electrostatically shielded "hairpin" inductively coupled to center-topped coils, as shown in Fig. 8. The balanced circuit arrangement reduces any reradiation from the local oscillator. On the broadcast band, a low-impedance loop antenna is used, composed of a single turn of two-conductor 75-ohm polyethylene-insulated transmission line, cross connected to produce two turns.

Switching of bands is accomplished with but two switch wafers, as shown in Fig. 14. Perhaps most indicative of the extent to which parts have been eliminated is the tuning capacitor, shown in Fig. [illegible]. This comprises but two variable sections, a split-stator unit (with c[illegible]per stator plates) for local oscillator tuning, and a conventional section for tuning the broadcast-band loop.

No tuning is used in the antenna circuits for shortwave and f-m services. These input circuits are designed as broadband fixed-tuned circuits which accept the whole band. The bandpass characteristic of the antenna input circuit for the f-m band is shown in Fig. 10. As shown, the band from 88 to 108 mc is contained within this curve, with voltage gain ranging from 0.2 at the band edges, to 1.4 and 0.9 respectively at the two peaks. A similar curve for the shortwave input circuit covers the range from 9.2 to 12 mc, with voltage gains ranging from 4 to 40 over the band.

Although these variations in gain introduce corresponding variations in sensitivity over the s-w and f-m bands, the overall sensitivity at the lowest points is still well above the usual performance, and the saving in component and assembly cost due to the elimination of an extra capacitor gang and switching is well justified. The overall sensitivity as a function of frequency in each band is illustrated in Fig. 11.

Further simplification in switching is obtained by the use of an unusual local oscillator circuit. The two halves of the split-stator capacitor, Fig. 9, are connected in series for tuning the f-m band, thus producing a low capacitance (about 29 $\mu\mu$f) which tunes the single-turn silver-plated oscillator coil, shown at the front in Fig. 9. Soldered directly at the ends of this turn is a temperature-compensating 53-$\mu\mu$f ceramic fixed capacitor.

The solid mechanical structure of this assembly, the high-capacitance design, plus the temperature compensation produce a highly stable oscillator. Drift is less than 20 kc under all normal operating conditions. The set may be tuned to any f-m channel from a cold start and requires no further retuning.

For tuning the shortwave and broadcast bands, the split-stator unit is connected in the parallel connection and additional induc-

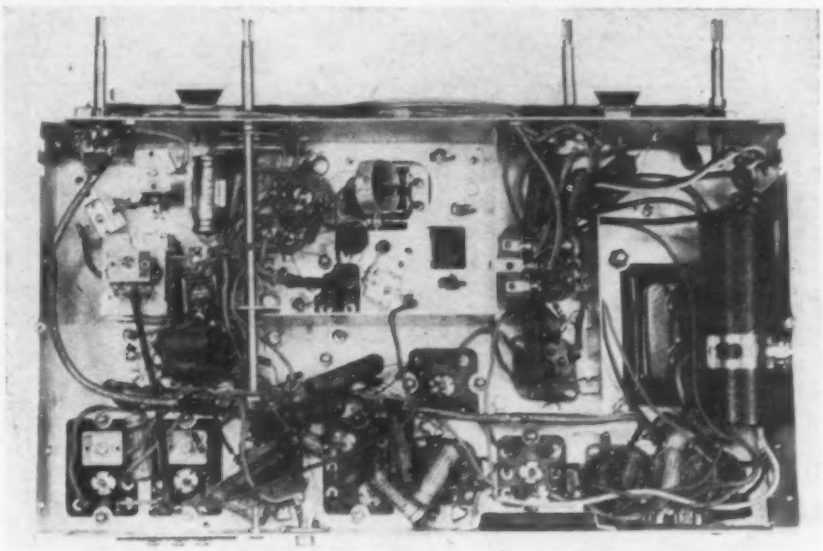


FIG. 3—Layout of components provides short leads for high frequency bands

# A New Approach to F-M/A-M Receiver Design

**An eight-tube double superheterodyne, with one of the local oscillators crystal- controlled, achieves unusual selectivity, sensitivity and low noise on broadcast, shortwave and f-m bands, with a minimum of components .**

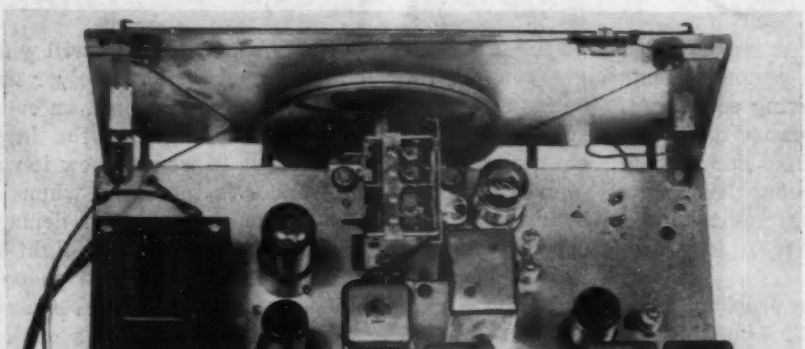


FIG. 1—Simple chassis layout speeds production

FOR years the complaint has been heard that there have been no new ideas in the design of broadcast and shortwave receivers. The editors of ELECTRONICS were resigned to this state of affairs when Mr. B. V. K. French, who qualifies as a neutral observer, called their attention to a radio receiver incorporating many unusual engineering techniques. This receiver is the model 86CR produced by the Crosley Division of the AVCO Corp. Thus encouraged, the editors approached the Crosley organization for full details, which were graciously supplied and are herewith presented.

The receiver, chassis views of which are shown in Figs. 1, 2 and 3, is an eight-tube double superheterodyne which covers the broadcast band, a bandspread shortwave band including the 25 and 31 meter regions, and the f-m band. The aim of the design was to produce a "hot" receiver, that is, one having very high sensitivity and low noise on all bands, free from spurious responses, using a minimum of component parts, simple enough to be produced on a high-speed line, and stable enough to satisfy consumer requirements, particularly with respect to tuning.

The sensitivity on the various bands is illustrated in Fig. 4. One watt of audio power, using the RMA standard input signal (modulated 400 cps, 30-percent a-m or 22.5-kc deviation f-m), is obtained with an average input of 20 microvolts on the f-m band, 3.7 microvolts on the a-m shortwave band, and 2.5 microvolts on the a-m broad cast band.

The noise output at full audio gain, shown also in Fig. 4, is below 35 milliwatts on shortwave, and it is suppressed by a 20-microvolt input signal; on a-m broadcast using a built-in loop the noise does not exceed 500 milliwatts even with very weak input signals, and is suppressed by a 200-microvolt input signal. On f-m, the noise has the unusually low figure of 1 to 4 milliwatts independent of input. This value is so low that, in tuning from one station to another in the f-m band, no hiss is heard between stations unless the audio gain is wide open.

Freedom from spurious responses, so necessary in a highly sensitive receiver, is obtained without employing an r-f stage. Instead, the necessary selectivity against such responses is obtained, in the a-m bands, by a double superheterodyne circuit. The selectivity achieved by this arrangement is shown in Fig. 5. The response curves have a bandpass shape which maximizes the ratio of audio fidelity to selectivity. The receiver was not designed for the highest possible

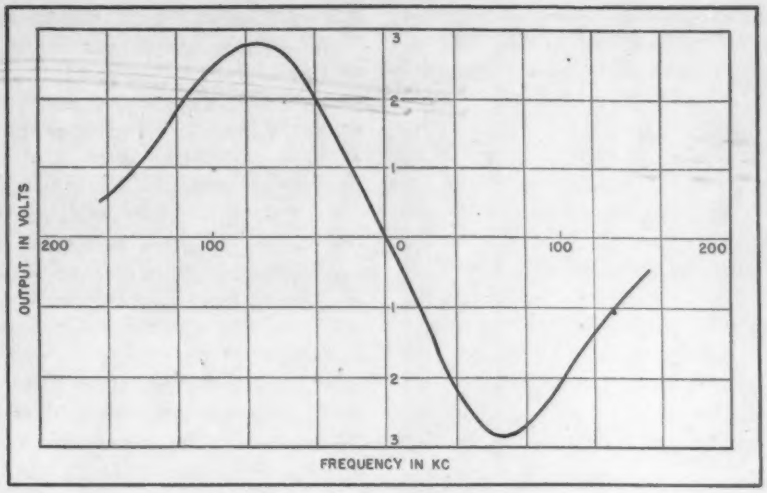



FIG. 7—Overall characteristic of the f-m i-f channel at 60 microvolts input

The difference frequency of 167.5 kc is amplified in the second 6SG7 tube with a gain of 175. This i-f signal is then demodulated in the diode section of the 6SQ7, and the resultant amplified at audio by the same circuits as in the f-m case.

### Circuit Details

The complete circuit diagram of the model 86CR receiver is shown in Fig. 14. Consider first the broadcast band, in which position the wave-change switch is shown. The loop and loading coil, tuned by the larger of the two ganged capacitors, (Fig. 9) are connected to the wave-change switch (rear of section 1, tap 7 and tap 10) to the grid of the first mixer. The loading coil acts as a 5825-kc trap.

The local oscillator operates at broadcast frequency plus 5,825 kc, by virtue of the connection through taps 2, 3, and 5 on the front of wafer section 1. These connect coils 15 and 16 and capacitors 56 and 130 between the grid and plate of the first local oscillator. The local oscillator tuning capacitor has its two sections (28B) connected in parallel by the single-turn coil (24) which acts as a short circuit at the local oscillator frequencies from 540 to 1,600 kc, plus 5,825 kc.

The intermediate frequency thus developed is passed by the first mixer to the 5,825-kc i-f transformer (coils 11, 20, and 19). The capacitors shown immediately below are connected, by the front and rear sections of wafer section 2, across the input and output coils of this transformer, thus tuning them to 5,825 kc. The link coupling (20) between coils 11 and 19 is also tuned to this frequency, so the whole transformer acts as a four-circuit transformer, having a double-humped bandpass curve.

The output of this transformer is passed to the second mixer. The second local oscillator, its plate energized through tap 1 of the front section, wafer 2, oscillates at 5,992.5 kc and its output is capacitively coupled through the rear section of wafer 2, to the grid of the second mixer, thereby developing the second i-f of 167.5 kc. This signal is passed through a dual-purpose i-f transformer which passes either the 167.5 kc or the 10.7 mc i-f, without switching, by virtue of the tuned circuits in series. The upper pair of circuits in the diagram are effectively short circuits at 167.5 kc, so only the lower pair operate. The 167.5-kc i-f is thus passed to the 6SG7 amplifier and thence to another dual-purpose coupling unit. The lower units are resonant at 167.5 kc, while the upper units (the 10.7-mc discriminator primary coil) is effectively a short circuit.

The 167.5-kc coupling unit passes the signal to the diode of the 6SQ7, where it is detected and passed, through the rear of wafer 2, to the triode section of the same tube. The tone control in the plate circuit of this triode is an unusual two-section unit, consisting of two isolated resistance segments, one across a capacitor in the bass-compensating

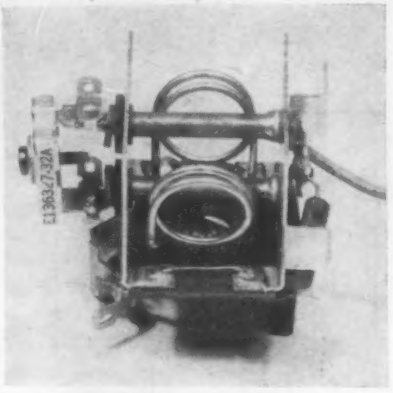



FIG. 8—The balanced antenna transformer employs electrostatic shielding

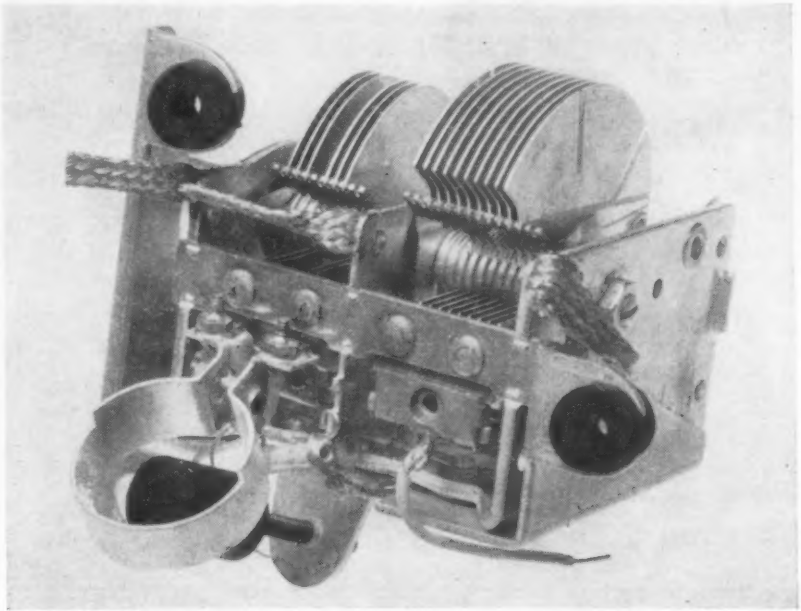


FIG. 9—Front-end tuning assembly. The single-turn coil permits use of a high-C oscillator for the f-m band

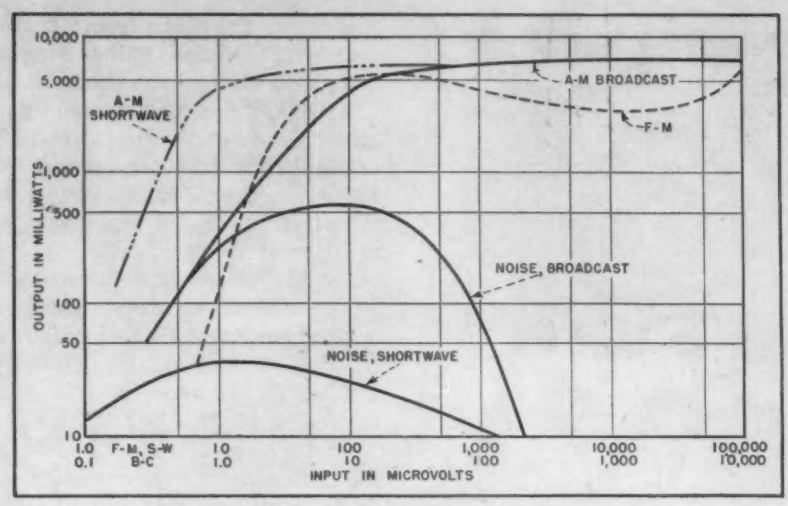



**FIG. 4—Overall sensitivity curves. The noise on the f-m range is one to four milliwatts**

tances are switched to the center tap of the single-turn coil. Both local oscillator connections form Colpitts circuits, and the change from one to the other requires only two switch points. The local oscillator feeds 2.5 volts to the converter.

The second local oscillator, connected by the switch when in the shortwave and broadcast positions, is a crystal oscillator circuit, which requires only two components in addition to the tube, the crystal itself and a fixed resistor. The crystal, operating at 5,992.5 kc, is a hermetically sealed unit, shown in Fig. 12. This unusual mounting, derived from similar housings used in high-quality paper capacitors, offers high stability and low cost (the cost of the crystal and assembly is well under one dollar). When the set was first designed an ordinary tuned-circuit was used in the second local oscillator but this proved difficult to adjust, both in factory alignment and in field servicing. Even a minor shift in the second local oscillator frequency would so disturb the tuning as to make alignment of the first local oscillator very difficult. The adoption of the crystal-controlled circuit solved these problems at a stroke, and the alignment is now no more difficult than that of a conventional single superheterodyne.

### Tube Lineup F-M A-M

Block diagrams for the f-m and a-m connections are shown in Fig. 13. In the f-m position of the wave-change switch, the first tube is the mixer, type 6AC7 with bandpass tuning. It offers the unusually high conversion gain of 40 times. The local oscillator, one half of a 7F8 double triode, is tuned through the range from 98.7 to 118.7 mc. This places the intermediate frequency at the usual value, 10.7 mc, for f-m service. The two following tubes, type 6SG7, act as i-f amplifiers, with a gain of 50 per stage. Following is a 6H6 double diode in a conventional Foster-Seeley discriminator, adjusted for 12 volts output per volt input to the discriminator with 22.5-kc deviation.

The audio output is passed to the triode section of a 6SQ7 diode-triode and thence to a 6V6 beam power output stage. Maximum power output is 8 watts.

For a-m service the double superheterodyne connection, shown at the bottom of Fig. 13, is used. The 6AC7 converter (now the first

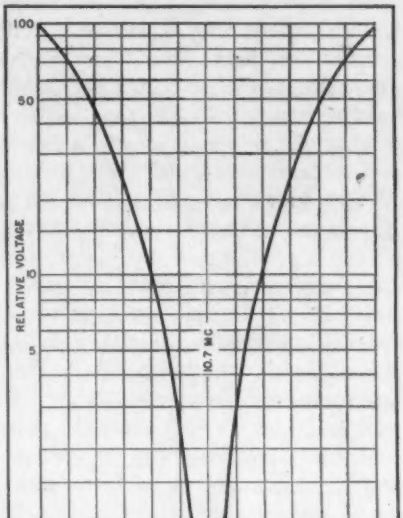



**FIG. 6—Bandpass characteristic of the first i-f transformer for f-m**

mixer) displays a conversion gain of 20 times in this circuit. The first local oscillator signal is injected into the first converter from the same local oscillator as in the f-m case, which is now switched to produce frequencies 5,825 kc higher than the incoming signal. Thus the first i-f frequency is 5,825 kc.

The 5,825-kc i-f signal is passed to the first of the 6SG7 tubes, now switched to operate as a second mixer, with a conversion gain of about 50 times. Mixed in this stage is the second local oscillator frequency, 5,992.5 kc, obtained from the crystal oscillator in the second section of the 7F8 double triode.

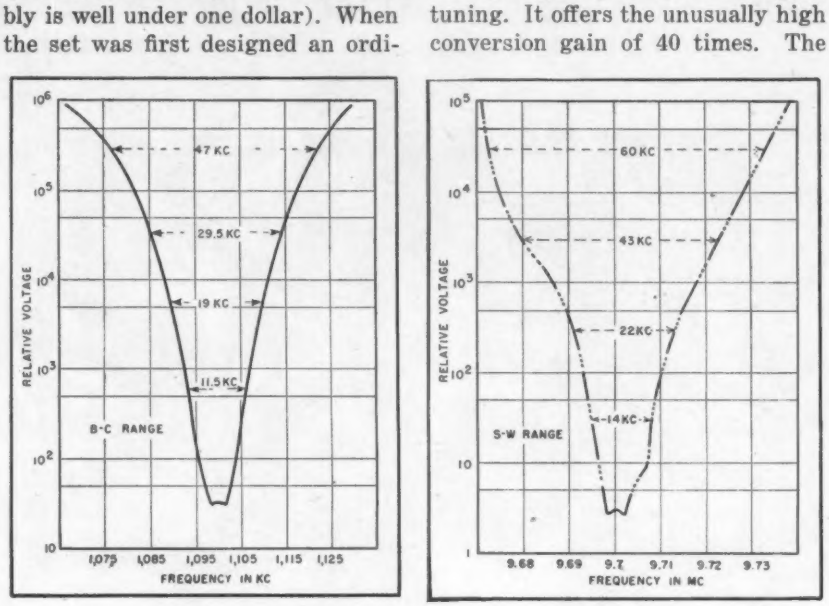



**FIG. 5—Selectivity curves for the two a-m bands**

and capacitor 123 (shown to left of the front portion of wafer section 2) becomes effective between the input and output of the i-f transformer. These changes tune the transformer to 10.7 mc. Coil 20, at 10.7 mc is effectively an open circuit, and the link coupling between the input and output coils becomes aperiodic.

After passage through the 6SG7 first i-f amplifier, the 10.7-mc signal is passed through the second i-f transformer, which transfers from 167.5 kc to 10.7 mc operation without switching. In the f-m position, the upper tuned circuits of this unit (80 and 81) are resonant at 10.7 mc, while the lower circuits in effect constitute short circuits (being tuned to 167.5 kc). This transformer preserves the double-humped response characteristic.

The signal then passes through the second 6SG7 i-f amplifier to the discriminator transformer. The audio output of the discriminator is switched by the rear of wafer 2 to the grid of the 6SQ7 audio tube, and thence to the power output stage.

The audio fidelity on f-m is the same as on a-m. This is one of the few design decisions with which this reviewer would disagree. The explanation given by the designers is that an extension of the higher frequency range, desirable as it might be in f-m service, would require more power output for low audio frequencies than is available from the chassis.

In view of the desire to secure high sensitivity and low noise at the lowest possible cost, the upper audio frequencies are substantially attenuated. Audio output as high as 8,000 cps is audible when the tone control is in the mid position, but the receiver is not flat to this level.

The 86CR receiver design was conceived and directed by John D. Reid, manager of research and development of the Crosley Division. Messrs. Bass, Cohen, Holst, Kilgour and Swceney, engineers of the Division, made substantial contributions and did the actual development work.—D.G.F.

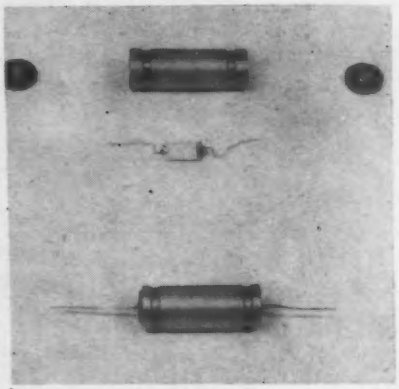


**FIG. 12—Simple construction of the hermetically sealed quartz crystal unit. Little more than an inch long, it mounts like a paper bypass capacitor**

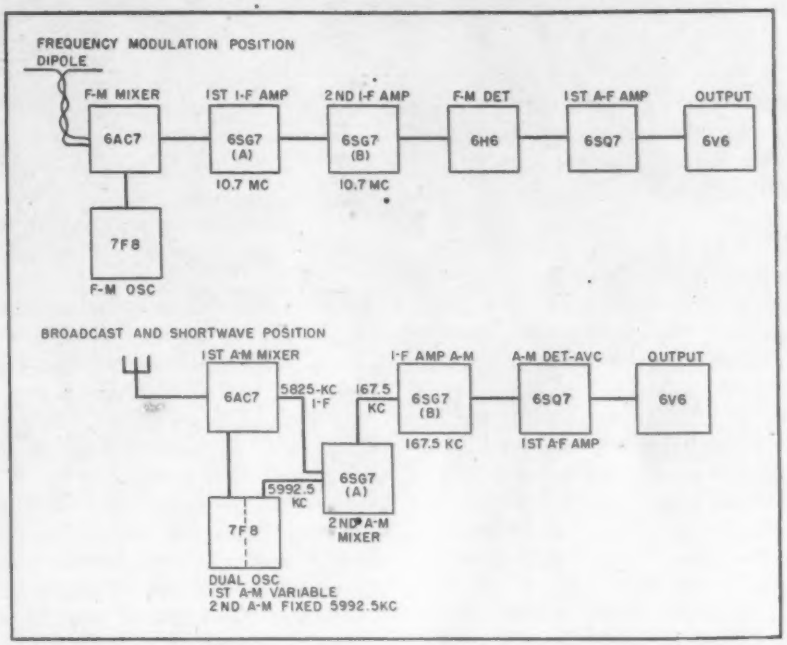



**FIG. 13—Arrangement of the stages for f-m and the two a-m bands**

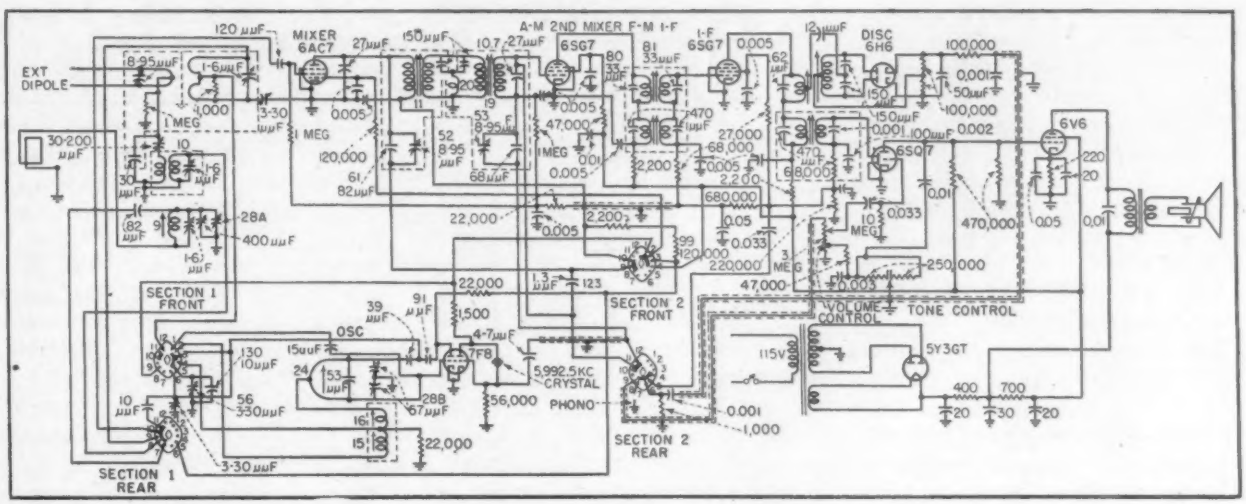



**FIG. 14—Complete circuit of the Crosley model 86CR receiver. The band switch is in the b-c position, s-w, f-m, and phono are successively clockwise**

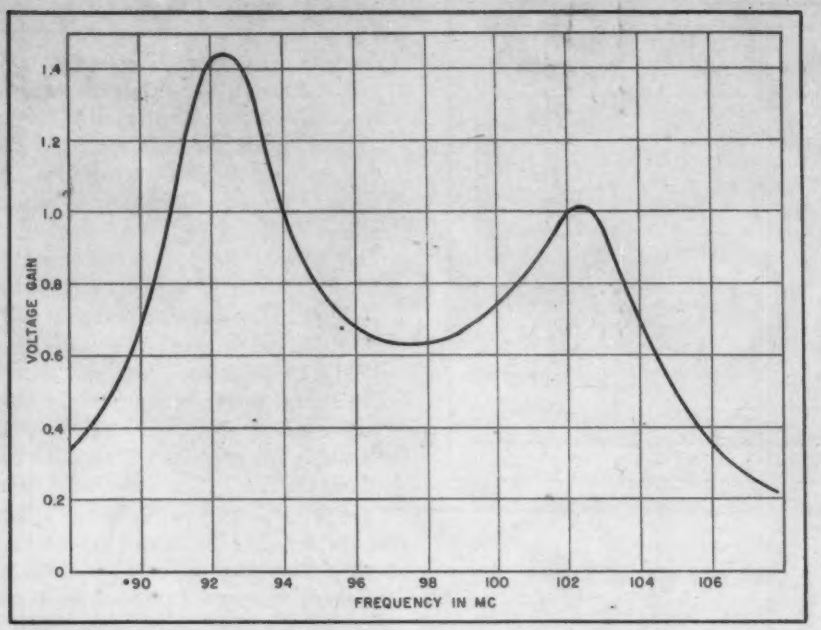



**FIG. 10—Bandpass characteristic of the antenna input circuit in the f-m position. The band from 88 to 108 mc is covered without tuning, and with unusually low noise level, by a high-gm pentode converter stage**

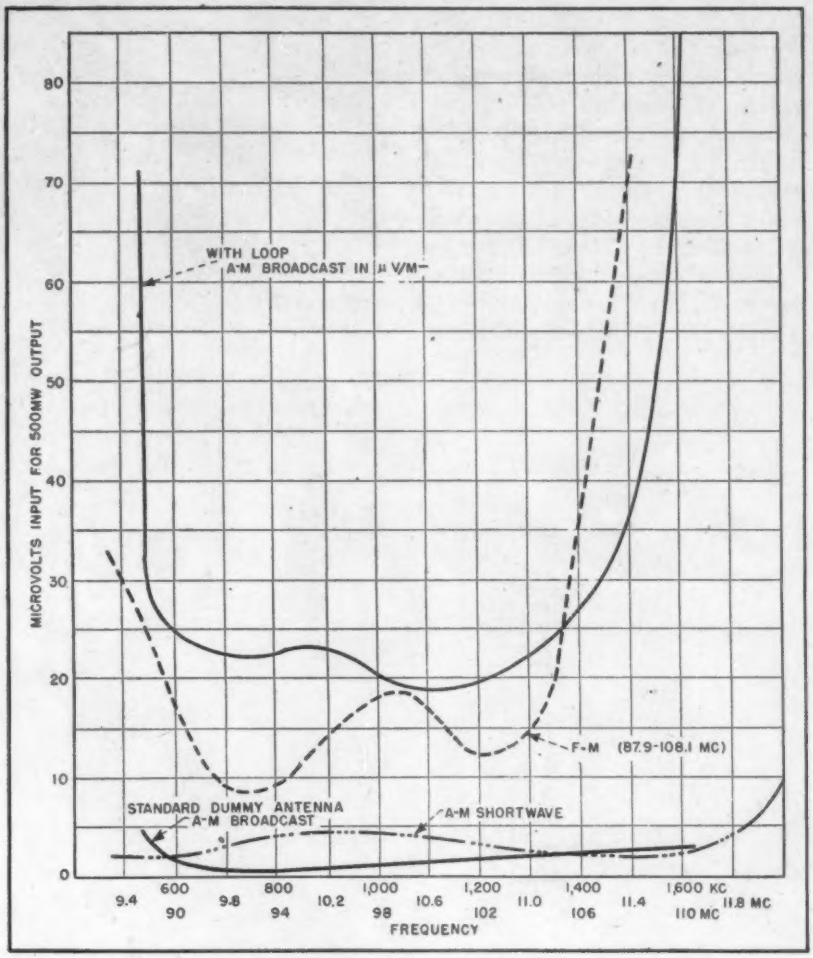



**FIG. 11—Overall sensitivity curves as functions of frequency over the three bands. The variation in sensitivity over the f-m band is due to the bandpass characteristic shown in Fig. 10**

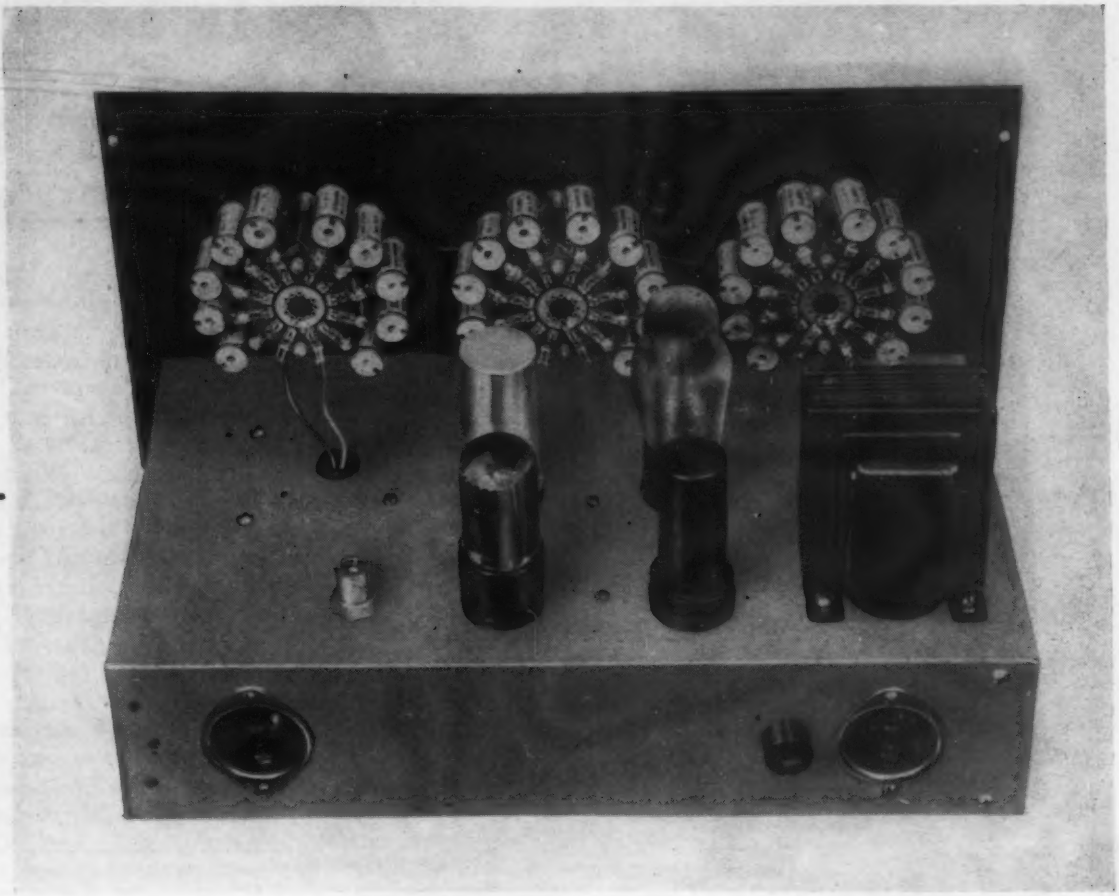
volume-control circuit, the other in series with a capacitor to the triode plate for attenuation of high audio frequencies. This arrangement provides an unusually wide range of tone control action with minimum use of parts.

In the shortwave position, the wave-change switch is rotated one tap clockwise. This disconnects the broadcast loop antenna, and connects in its place the shortwave bandpass (untuned) circuit, through taps 8 and 10 of the rear section, wafer 1, to the grid of the first mixer. The shortwave input circuit is connected to the center tap of the f-m input circuit primary, thus using the built-in f-m dipole and its transmission line as a T antenna for shortwave pick-up. The change from tap 8 to 4 on the front of wafer 1, removes section 15 of the local oscillator, thus shifting its frequency higher, so that it tunes from 9 to 12 mc, plus 5,825 kc.

In the f-m position, the wavechange switch is rotated clockwise to the next tap. Wafer 1 of the wavechange switch disconnects the shortwave coil, and connects the secondary of the f-m antenna coupler to the mixer grid. The coupler consists of the single-turn hairpin primary, coupled to the 70-ohm transmission line and dipole, the latter mounted in the cabinet. The shortwave primary now serves as an i-f trap for 10.7 mc. The hairpin is electrostatically shielded from the balanced secondary coils.

The local oscillator voltage is injected at the center tap of the coil, by virtue of the connection between taps 12 and 1, on the front of wafer section 1. Other taps on the same wafer remove coils 15 and 16 in the local oscillator circuit. The single-turn local-oscillator coil resonates at the f-m station frequencies plus 10.7 mc, and the split-stator capacitors, 28B, automatically assumes the series connection, without the necessity of switching. The plate voltage for the second local oscillator is disconnected in the f-m band position, since its output is not used.

The output of the mixer, the 10.7-mc i-f signal, is passed to the same i-f transformer as in the broadcast and shortwave positions. In the f-m position, however, capacitors 61, 52, 53 and 62 are disconnected



Chassis view of the interval timer, showing the precision wire-wound resistors that are selected by switch dials. A power supply is included on the same chassis

Substituting values shown in the circuit diagram, $t = 10 \times 3 \ln 150/5 = 102$ sec.

An examination of Eq. 1 shows that the timing circuit depends not only on the RC constant but also the initial potential of the capacitor, which may be further increased to obtain greater time periods. Another advantage of this circuit is the fact that the timing interval will always terminate. Leakage will shorten the timing period, rather than prevent its termination—a preferred condition.

### Relay Switching

Another problem to be considered when dealing with these types of timing circuits is that concerning the relays. The system shown exhibits none of the faults associated with several previous circuits investigated. Relay $K_1$ is a miniature type and operates on a current of about 20 milliamperes. The coil resistance is 1,500 ohms. The power relay operates from 115 volts a-c and draws about 4 watts. The contacts on this relay are rated at 15 amperes, noninductive load.

The circuit operates as follows: when the timing cycle is initiated, no current is flowing through any set of contacts on $K_1$. After this relay has opened, one set of contacts connects the coil of the power relay $K_2$ to the 115-volt a-c supply. One set of contacts on $K_2$ closes to connect the external circuit. The other set of contacts on this relay locks in the relay by connecting its coil to the a-c line in series with a 200-ohm resistor.

After this operation most of the current is removed from the contacts of the primary relay, preventing arcing of the inductive load as the armature pull increases to end the timing cycle. As the primary relay closes, one set of contacts shorts the coil of the secondary relay to open it and break the lock-in circuit. During this fraction of a second the 115 volt a-c supply is across the 200-ohm resistor.

It should be noted, in the above switching program, that the currents in the primary relay contacts are zero or very small on breaking sequences. All heavy currents are handled on contact make, when contact pressure is maximum, this fact insuring long life and trouble-free operation to the system.

### Choice of Components

Precision resistors accurate to plus or minus 1 percent have been used in the model shown. After a 15-minute warmup, the timer operates with an accuracy of plus or minus 2 percent or better. Another model constructed with standard metallized resistors gave a resulting accuracy within plus or minus 5 percent.

The timing capacitor $C_1$ must have a high resistance. Two commercial types found practical and inexpensive were a Tobe Filtermite rated at 3 $\mu$f, 600 volts d-c and a similar unit manufactured by Cornell-Dubilier.

By E. L. DEETER
and W. K. DAU

*Naval Ordnance Laboratory*
*Washington, D. C.*

# INTERVAL TIMER

**Timing periods in 0.1-second increments for the range 0.1 to 100 seconds can be set up on direct reading dials. The period depends upon reduction of control-tube bias by discharge of an RC circuit. High accuracy is attained using standard parts. A power relay in the output handles 15 amperes**

IN MANY INSTANCES it is desirable or necessary to control automatically the operating time of electrical devices. This is especially true when the time interval is to be of short duration. The high resistance required in a conventional type of RC circuit to obtain a useful range of time periods is, however, a disadvantage. When used in photographic darkrooms where a highly humid atmosphere exists, leakage over insulation surfaces of the circuit will greatly affect the calibration and operation. It is therefore desirable to increase the maximum time interval without increasing the size of the RC elements.

The timer to be described has proven itself reliable and has operated accurately over long periods of use. In the laboratory it has been used to furnish the timing cycle for such operations as induction soldering, photographic enlarging, and contact printing. The timer, which furnishes periods in 0.1 second increments from 0.1 second to 100 seconds, is built around a straightforward circuit, incorporating some interesting features.

### Basic Timing Circuit

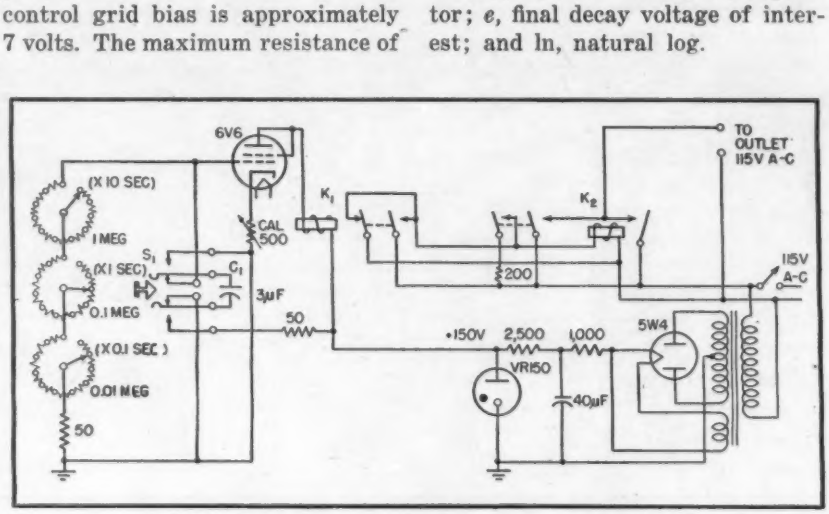
The schematic circuit diagram shows that the control grid is normally supplied with a small bias voltage. The value is low (about 2 volts), and is variable for calibration purposes. Operating with 150 volts on the plate, the tube resistance is such as to cause the relay to close during the nonoperating period of the instrument. During this period the charge on the RC-circuit capacitor $C_1$ will be low and always less than that bias which allows the relay $K_1$ to drop out.

A double-pole single-throw transfer switch $S_1$ initiates the timing interval. The switch is momentarily held over to place the capacitor across the regulated d-c supply of 150 volts, and then released to the normal position as shown. This action places a negative bias of 150 volts on the control grid of the 6V6 tube. The primary relay $K_1$ then opens to start the timing interval and $C_1$ begins to discharge through the timing resistors shunting the capacitor. The primary relay is adjusted to close when the current through the coil is about 6 milliamperes. This value results when the control grid bias is approximately 7 volts. The maximum resistance of the RC circuit is about 10 megohms and the capacitor is 3 $\mu$f, resulting in an RC constant of 30.

The timing period corresponds to that obtained in a more conventional circuit with an RC constant of 100, and is realized because the timing cycle is dependent on the decay voltage of $C_1$. The time required for the initial 150-volt potential of $C_1$ to decay to the required 5 volts (grid bias is the sum of the emf across the 6V6 cathode resistor and potential $e$ across $C_1$) is derived from the following equation.

$$t = RC \ln E/e \qquad (1)$$

Where $t$, decay time in seconds to obtain $e$; $RC$, = time constant, megohms × capacitance in microfarads; $E$, initial charge on capacitor; $e$, final decay voltage of interest; and ln, natural log.




**Schematic circuit diagram of the timer. The period is controlled by reduction of bias on the tube. Power is handled by the second relay $K_2$**

# FOR TELEVISION AND F-M

**Method of using a single four-bay Superturnstile antenna for simultaneous operation of an f-m transmitter and visual and aural transmitters of a television station, with power gain of 6.4 for f-m and 5 for television. Coupling between transmitters is negligible**

By L. J. WOLF *Engineering Products Division, RCA Victor Division Radio Corporation of America, Camden, New Jersey*

at ground potential. Currents will flow in the plane surface with a magnitude and instantaneous direction at the sides of the slot approximately as shown by the arrows. These currents will flow on both sides of the plane surface and will radiate equally on each side. This condition will be unaffected by openings in the plane surface as long as these openings are small compared with a wavelength.

### Radiator Feed

The radiators (Fig. 2) are mounted so that contact to the supporting pole is made at places of zero potential, hence are attached directly without the necessity of any sort of insulator. The feedline for a pair of radiators is brought from the pole onto the radiator over one of the two connecting brackets. At the center of the radiator, the feedline is brought around the pole, half way to the other radiator. The inner conductor connects to the other radiator through a cross-connection strap. Thus, with the outer conductor of the feedline connected to one radiator, and the inner conductor to the other radiator, a balanced feed results. The only insulation needed is that of the end seal on the end of the feedline.

The antenna described has four identical Superturnstile radiator sections. With these, the television power gain is approximately 5, and the f-m power gain is approximately 6.4 as compared to that of a half-wave dipole (without allowance for transmission line loss). The f-m gain is higher because the height in wavelengths is greater for frequency modulation than it is at the television frequency.

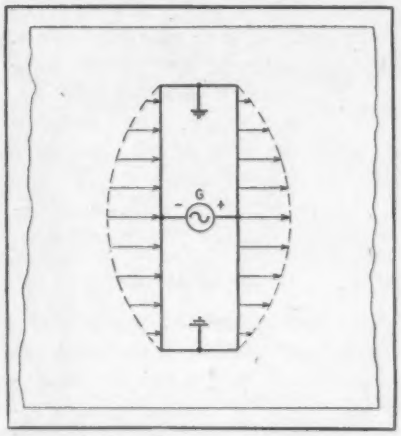
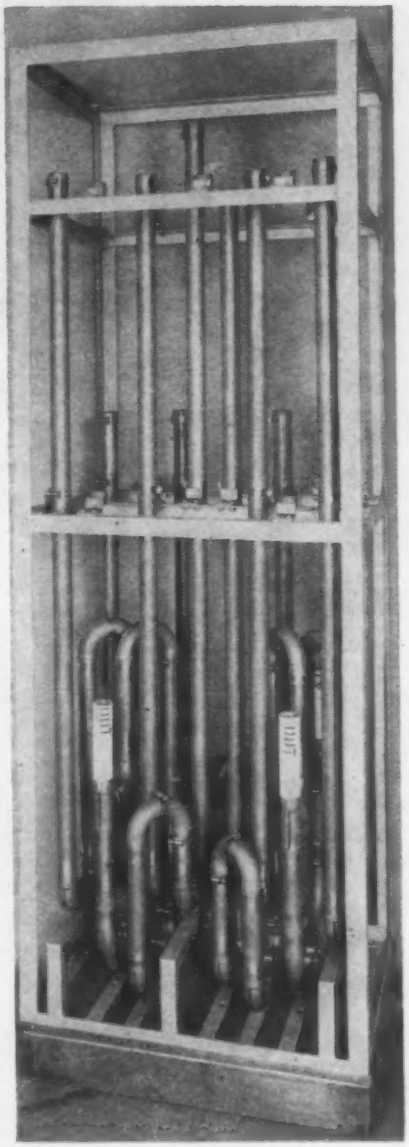



FIG. 3—Currents and voltages in the region of half-wave slot in large conducting plane simulating Superturnstile

### Transmission Line

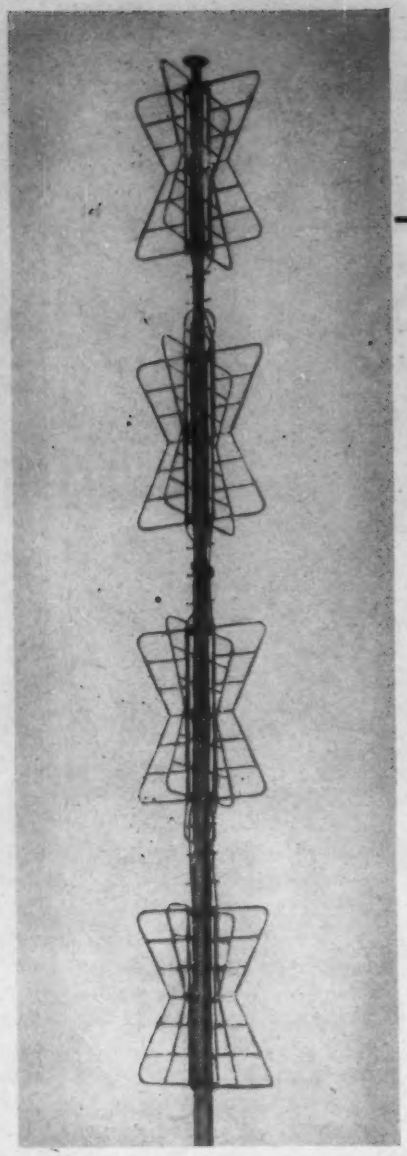
The transmission line between transmitter room and antenna consists of a pair of 3⅛-inch, 51½-ohm coaxial lines designed with conductors and insulators in accordance with RMA recommendations. Special design precautions have been taken to make certain that the lengths of line can be coupled in a satisfactory manner, and to eliminate electrical discontinuities at elbows and connections.

The 20-foot lengths of line are supplied with flanges brazed in place. These flanges are bolted together to join sections of line at installation, using O ring gaskets to keep the line pressure-tight. Differential expansion between the steel tower and the copper outer



Triplexing unit in transmitter room, showing the half and quarter-wave stub sections of coaxial line that are used to keep the signals in their proper paths

# TRIPLEX ANTENNA



Superturnstile antenna using four radiator sections, arranged for triplexing to serve simultaneously an f-m transmitter and both visual and aural transmitters of a television station

THE TELEVISION and f-m transmitters of the National Broadcasting Company radio stations WNBW and WRC-FM at Washington operate simultaneously into the same Superturnstile antenna system. This results in a considerable saving in the size of the antenna and in the cost of the supporting tower. The full power gain of the antenna is realized for each service, hence no increase in transmitter power is required for this kind of antenna operation.

The quadrature feed to the Superturnstile antenna makes possible the simultaneous or diplex operation of the visual and aural signals from the television transmitter into the antenna. The Superturnstile antenna has an input impedance characteristic which is sufficiently broad for the f-m transmitter to be readily coupled in through a triplexing arrangement.

### Superturnstile Radiator Theory

The turnstile type of antenna consists of crossed pairs of radiators, each being approximately a half-wave in length. The pairs are mounted at 90 degrees as in Fig. 1 and fed in quadrature with currents that are equal in magnitude but 90 degrees apart in phase.

The field in any direction from either of the radiators is approximately proportional to sin A, where A is the angle from the radiator. Thus, the maximum radiation from radiator E-W is transmitted in the north and south directions (where sin A is unity), while no field is transmitted from radiator N-S. Similarly, maximum radiation from radiator N-S is transmitted in the east and west directions, while none is transmitted east or west from radiator E-W.

In the northeast direction, the transmitted field is the resultant of radiation from both sets of radiators. Here sin A is 0.707 for each; these are added in 90 degrees quadrature since the currents are in quadrature, so the resultant is unity. For 30 degrees and 60 degrees the values added in quadrature are 0.5 and 0.866, again giving unity. Similarly, for other angles and other quadrants the radiated field is also close to unity.

### Radiator Construction

The basic Superturnstile radiator consists of an open framework of steel rods and tubes, with dimensions as shown in Fig. 2. Two of these radiators mounted at right angles on a tubular supporting steel pole form a radiating system that has a pattern and gain equivalent to two parallel dipoles spaced a half wavelength apart.

A pair of Superturnstile radiators may be considered as a large plane surface containing a slot. Figure 3 shows a flat conductor of large area, with a rectangular slot approximately a half-wave long. A generator *G* applies a-c voltage having an instantaneous polarity (as shown by the plus and minus signs) to the two terminals. Set up along the sides of the slot, a voltage will have a magnitude as represented by the distance of the dotted lines from the sides of the slot. The ends of the slot will be

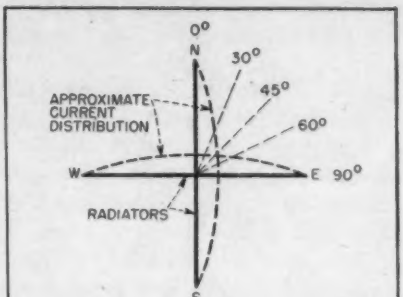



FIG. 1—Horizontal plane through radiators connected in turnstile arrangement

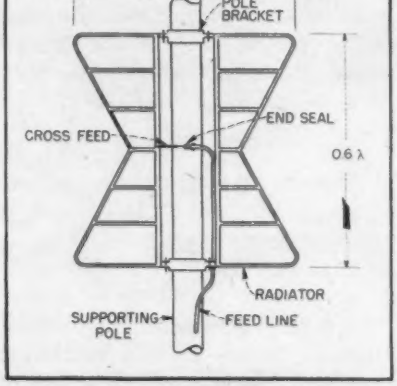



FIG. 2—One pair of Superturnstile radiators mounted on steel pole. Other pair is at right angles to these, using same pole brackets

are separated by a greater percentage than are television visual and aural frequencies, frequency-selective circuits are used in the triplexer.

Figure 5 illustrates the fundamental triplexing circuits used. The television transmitter *TV* feeds the antenna load directly as in Fig. 5A, with two half-wave circuits *H*, connected to the main line through two quarter-wave circuits *q* which are separated a quarter-wave apart along the main line. Each branch (consisting of an *H* and a *q* in series) is three-quarter-wave long, hence presents a high impedance to the main line. The characteristic impedance of these branch line elements is chosen so that this high impedance is presented to the main line over a band which is at least six megacycles wide.

The circuits associated with the f-m transmitter are added as in Fig. 5B. Circuits *H* are extended by stub sections *h*. The lower *h* stub is adjusted so that the combination of reactances presents a low impedance, or short-circuit at terminal *S* at the frequency of transmitter *F-M*. The upper *h* stub is adjusted so that the input impedance, looking to the antenna from *F-M*, is also matched at the f-m frequency. The voltage magnitudes under this condition are represented by the dotted lines.

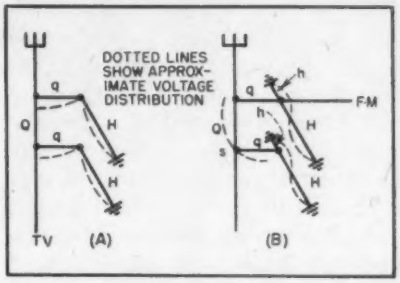


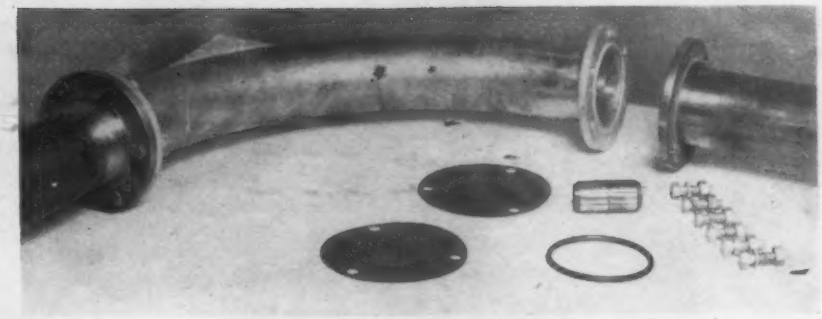

**FIG. 5—Fundamental circuit of triplexer (A) showing use of two frequency-selective tuned elements, and method of adding stub elements (B) for coupling an f-m transmitter. Circuit lines represent inner conductors of coaxial lines, and ground symbol indicates shorting plug in line**

### Combined Diplex and Triplex System

In the complete system as used at stations WNBW and WRC-FM, a four-section Superturnstile antenna is used as shown diagrammatically in Fig. 6. The E-W and N-S radiators are fed from junction boxes *JB*. The feedlines from the junction boxes are all the same length, so the radiators will all be fed in phase. Each junction box assembly contains a series line transformer, to match the 51½-ohm transmission line to the impedance of the four feedlines in parallel.

The twin transmission lines going down the tower are equal in length between the junction boxes and the triplexer so the phase relationship between lines, as established at the transmitter, will be maintained at the antenna. The lines are carefully installed so that the elbows in the two lines are equally spaced from the triplexer.

The triplexer is located in the transmitter room, with the two transmission lines passing through it to the diplexer. The internal circuit of the triplexer consists of matched pairs of transmission line elements.



**Flange connections used on transmission lines for Superturnstile**

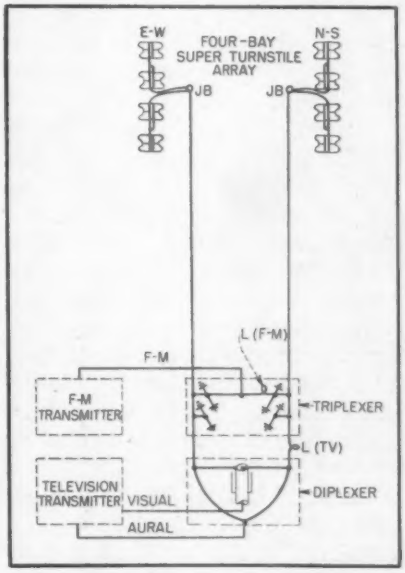



**FIG. 6—Complete triplexing system, with N-S and E-W radiators shown separately to clarify connections. Circuit lines are inner conductors of coaxial lines**

The f-m feed into the triplexer divides as shown, with one side going through a phasing loop. This loop is a quarter-wavelength at the f-m frequency and provides the correct quadrature phase required to give a circular pattern from the turnstile antenna. Only the f-m feed is through this loop; the quadrature loop for television is separate. This arrangement provides a convenient method of maintaining the correct quadrature feeds for the two systems, even though the frequencies are different.

The diplexer terminates the two separate antenna transmission lines. One line between triplexer and diplexer is made a quarter-wave longer than the other at the television frequency. This quadrature length is separate from the f-m loop, hence sets the correct phase relationship for television independently of the f-m requirement.

The diplexer contains the visual input circuit, consisting of a single-ended circuit with a balun to convert to double-ended feed. The balun is suitably compensated to be broad-band so that it does not introduce any appreciable discontinuity over the television channel. The aural input circuit is single-ended and connects to a point where no visual voltage exists, so there is negligible coupling between visual and aural power amplifiers.

Acknowledgement is made to the members of the Television Broadcast Antenna Group of RCA Victor Division, who not only designed this equipment but also made it work, and to the engineers of the Radio Facilities Group of the National Broadcasting Company, who bore the brunt of getting the first equipment installed.

conductor of the transmission line is provided for by means of spring-hung tower brackets, which permit the line to expand and contract vertically. The line is secured at the top of the tower so that the expansion occurs entirely at the bottom of the tower. Differential expansion of the inner conductor with respect to the outer conductor is allowed for at each flanged connection; the inner conductor connector is of the push-type which allows the inner conductors to slide a slight amount as required.

Electrical discontinuities are minimized as far as possible at bends by providing elbows with a radius which is large compared to the line diameter.

Inasmuch as the E-W and N-S radiators of the antenna are fed in quadrature, the two transmission lines must be kept alike, so that the two lines will maintain at the antenna the correct phase relationship set up at the transmitter. This is accomplished by making the two lines identical as regards lengths of line sections and placement of elbows. The quadrature phase relationship is introduced at the diplexer by making one line 90 degrees longer than the other.

Pressurization of the transmission lines is maintained by an automatic dehydrator which keeps a small positive pressure of dry air on the line at all times.

The diplexing unit consists of a Wheatstone bridge type of network which provides a means of feeding the visual and aural energy of the television transmitter into the antenna without detrimental cross-coupling effects.

### Diplexer

In the fundamental diplexing circuit of Fig. 4A, the resistors represent the loads due to the radiators N-S and E-W respectively. The visual power amplifier feeds push-pull to terminals *T*. The aural power amplifiers feeds via a single-ended line through reactances *X* to terminals *T*. The two transmitter sources are uncoupled from each other as long as the two loads and the two reactances are equal respectively. Thus, no cross-feed between transmitter sources will exist, even for modulation sideband components which are nearly identical in frequency.

The physical realization of the bridge circuit is indicated in Fig. 4B. Each connection line represents the inner conductor of a coaxial transmission line. The outer conductors are not shown except for the cylindrical balun sleeve on the connection to the visual transmitter. The visual transmitter feed is single-ended, hence is changed to a double-ended feed by means of this balun. The visual feed is push-pull at terminals *T*, whereas the aural feed is push-push at these same terminals. Loop *L* represents the extra quarter-wavelength of line that provides the quadrature feed of the E-W radiators with respect to the N-S radiators.

Elements *X* are transmission lines which are each a quarter-wave

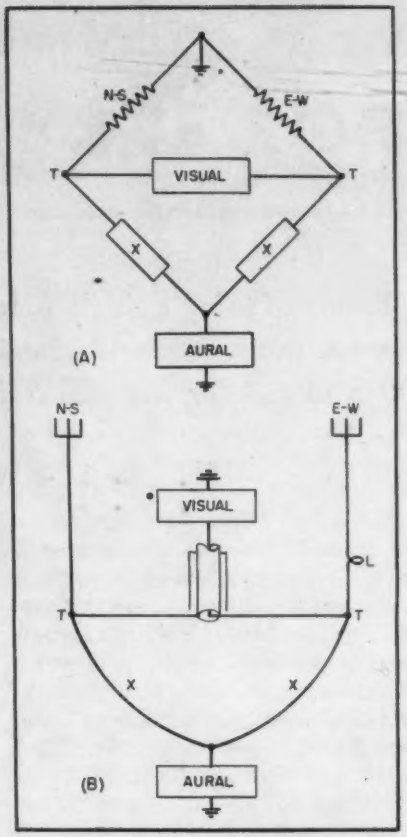


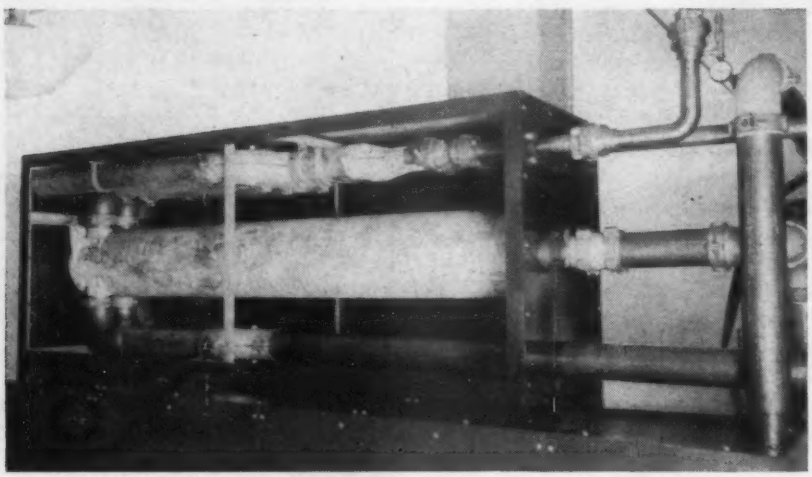

**FIG. 4—Fundamental bridge-type diplexing circuit, (A) and practical application (B) to visual-aural diplexing system of television transmitter. Circuit lines represent inner conductors of coaxial lines**

long at the midvisual frequency, which totals a half-wave in length. This length of a half-wave on terminals *T* shunts a high impedance across the visual input circuit. Conversely, terminals *T* are at the same potential with reference to each other at the aural frequency, hence no aural power can couple into the visual transmitter input.

This bridge-type circuit is particularly useful for coupling the visual and aural power amplifiers since the transmitter frequencies are quite close together. The reactance of the circuit elements changes very little from one frequency to the other, hence has no serious detuning effect on either power amplifier.

### Triplexing System

The triplexing unit allows the power from the f-m transmitter to be coupled onto the line to the antenna, with the correct phase relationships, without cross-coupling to the television transmitter. Since the television and f-m frequencies



**Diplexing unit in transmitter room. Larger lines bring in power from visual and aural power amplifiers, while two smaller lines go to antenna via triplexing unit**

Four single-cycle multivibrators controlled by a free-running multivibrator serve as an adjustable electronic switch for cathode-ray oscilloscopes, generation of square waves, investigation of code intelligibility in communications systems, and general audio research

By R. G. ROUSH
*Systems Research Laboratory*
*The Johns Hopkins University*
*Baltimore, Maryland*

# GENERATOR

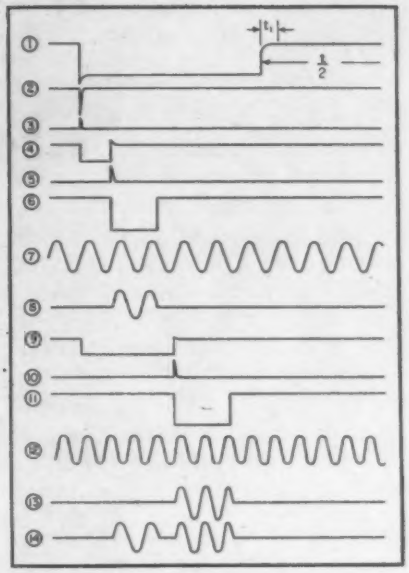


FIG. 2—Waveforms at various numbered points in Fig. 1

two sine-wave input signals. The tone burst obtained from the channel whose input signal supplies synchronization will therefore be turned on and off at the same points in the cycle during each period of the repetition rate. By means of the delay and tone duration controls, these points may be selected at will, thus causing the gated tone to consist of any portion of a cycle or of any number of cycles as desired.

### Trigger Generator Circuit

The multivibrator in the trigger generator circuit of Fig. 3 provides a reference timing voltage which can be varied in repetition rate from 120 cycles per second to 1 cycle in 20 seconds. It is a conventional free-running balanced multivibrator in which variable repetition rates are produced by varying the relaxation time constants uniformly in both grid circuits. The coarse adjustment permits the selection of four ranges of repetition rate by selecting four different values of capacitance in each grid circuit. Fine adjustments are made by equal variations in grid leak resistors $R_3$ and $R_4$, whose shafts are mechanically coupled.

The timing voltage is obtained from the plate of $V_{1B}$ and is essentially of rectangular waveform. The negative drop in this waveform was chosen as the timing reference because a steep wave front is obtainable and, by use of $R_5$ and $R_6$ and proper circuit adjustment, the amplitude of this reference voltage can be made constant over the entire frequency range of the multivibrator. These resistors limit the minimum period of the multivibrator waveform on any one range setting to a value which is twice as great as the exponential rise time of the positive portion of the multivibrator output; in other words, the minimum value of $t/2$ in Fig. 2 is $t_1$, where $t_1$ is the exponential rise time and $t$ is the period of the multivibrator. The plate voltage of $V_{1B}$ therefore has sufficient time to reach its maximum value before conduction again occurs.

In order that the negative change be isolated from the remaining portion of waveform 1 in Fig. 2 to produce the timing reference, the multivibrator output is applied to an R-C differentiating circuit, a positive clipper, and a phase inverter.

When the input voltage to the differentiating circuit rises to the 218-volt condition, the cathode of $V_{2A}$ is positively biased and prevents conduction. Capacitor $C_9$ therefore charges through $R_7$. When the negative drop occurs, the cathode of $V_{2A}$ is lowered below ground potential by the amount of the drop, thus permitting $C_9$ to discharge through the additional path offered by the d-c resistance of $V_{2A}$, $R_8$, and $R_9$. The resulting waveform across $R_9$ is a negative trigger of approximately 11 volts amplitude, having a duration of 15 microseconds at the 4-volt level. This trigger is inverted and amplified by $V_{2B}$. The output of the trigger generator is therefore a positive trigger which may be

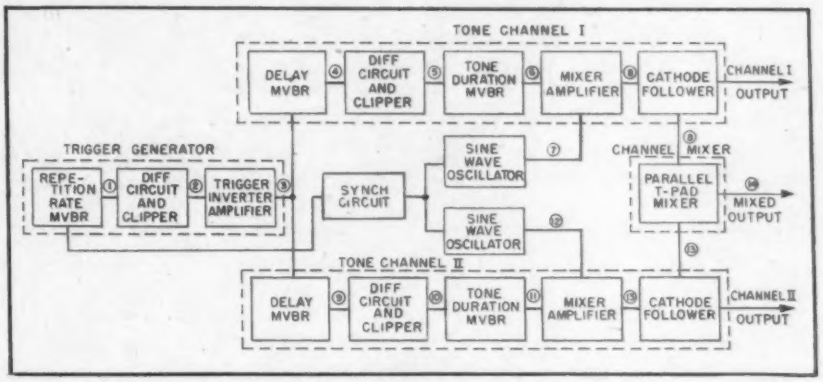
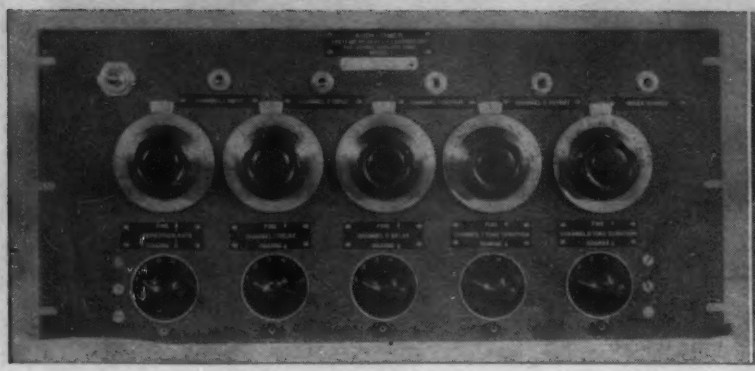
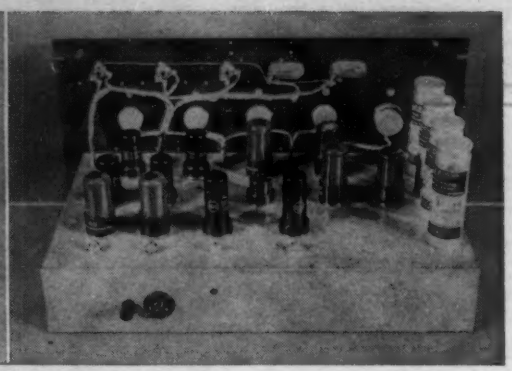



FIG. 1—Block diagram of complete electronic keying system for producing controllable short bursts of two different audio tones



Front panel of audio burst generator. Dials and switches serve as fine and coarse controls for repetition rate, channel 1 delay, channel 2 delay, channel 1 tone duration, and channel 2 duration. Jacks at top are for input and output of the two channels and for mixer output, to extend use of instrument



Rear view of generator. The required regulated power supply is on a separate chassis. Test point jacks at bottom of front panel permit extraction of the multivibrator voltages for other uses

# TONE BURST

In a long-range investigation of perception or understandability of code messages transmitted over communications systems, a signal generator was needed that would produce short bursts of two different tones, with the tone bursts independently controllable as to duration and spacing and with the repetition rates of the two tones synchronously related. With such a universal two-tone automatic electronic generator of code signals, complete control over all parameters that might affect intelligibility would be achieved.

To provide a source of these tone bursts, an electronic keying circuit was designed which would permit two tones to be independently turned on for variable time durations and at variable repetition rates. The four basic units in this audio timer are a trigger generator, two tone channels, and a channel mixer, arranged according to the block diagram in Fig. 1.

The trigger generator provides a synchronizing trigger voltage, variable in repetition rate from 120 per second to one in 20 seconds, which is used to start each of the tone channels on their individual operating cycles. The trigger voltage is derived from the output waveform of a balanced free-running multivibrator by means of a differentiating circuit, a positive clipper, and a phase inverter. The output is a positive trigger, which may be varied in repetition rate by adjustment of the multivibrator frequency. Waveforms at the various numbered points in Fig. 1 are shown in Fig. 2.

The output of the trigger generator is applied to tone channels I and II, which are identical. Each channel contains two single-cycle multivibrators, designated as the delay multivibrator and the tone duration multivibrator.

The trigger from the trigger generator serves to start the delay multivibrator on its operating cycle. The duration of the cycle is variable by means of fine and coarse delay adjustments. The output voltage of this circuit is a negative rectangular wave, the leading edge being coincident with that of the trigger generator output and the trailing edge possessing the desired amount of delay.

The negative output waveform of the delay multivibrator is differentiated and negatively clipped to give at point 5 a positive trigger voltage that coincides in time with the trailing edge of the delay multivibrator output and will therefore be variable in delay with respect to the trigger generator output. This delay is adjustable from 0 to 2,000 milliseconds.

The delayed trigger is applied to the tone duration multivibrator and is used to initiate the operating cycle of this circuit. The output waveform of this multivibrator is a negative gate whose leading edge is coincident with that of the delayed trigger. The width of this gate is variable from 0 to 3,000 milliseconds by means of fine and coarse tone duration controls.

The output of the tone duration multivibrator is applied to a mixing circuit which has an additional input consisting of a continuous audio sine wave. The circuit is adjusted so that the sine wave can only appear in the output when the gate is present. By means of a d-c balance control all d-c components may be removed from this output so that it consists only of a burst of tone at point 8 appearing above and below a zero reference level. The start of this tone may be delayed from the reference trigger, and the tone itself may be varied in duration.

The output of the mixing circuit in each channel is applied to a cathode follower in order that a low output impedance may be realized. The output of each cathode follower is applied to the channel mixer (a parallel T-pad network) which mixes the outputs of the two channels and provides approximately 10-db attenuation in each channel. The output of this circuit therefore consists of the tone bursts of each channel, each of which may be independently varied in duration or delayed with respect to the other. The individual channel outputs may be obtained without mixing.

To obtain synchronous operation of the timer, provision has been made for synchronization of the repetition rate with either of the

continuously varied in period from 8 milliseconds to 20 seconds.

### Tone Channel Circuits

The delay multivibrator in the tone channel circuit in Fig. 4, used to produce a variable delay period between the trigger generator output and the start of an audio tone introduced at a later point in the circuit, is a conventional single-cycle multivibrator in which feedback is obtained through common cathode resistor $R_{13}$. With the selector switch in position 1, there is no coupling between the plate of $V_{3A}$ and the grid of $V_{3B}$. The latter triode has its control grid returned to −210 volts through $R_{15}$ and is therefore in a nonconducting state. In its quiescent condition, $V_{3A}$ is operating as a class A amplifier with self bias. When the trigger generator output arrives, $V_{3A}$ is instantly driven to saturation and returned to the original condition, thus producing a trigger of the same polarity but of smaller amplitude across $R_{13}$. The output of the delay multivibrator is taken from the common cathode connection and is therefore a positive trigger which is coincident in time with the trigger generator output.

For coarse delay switch settings 2 and 3, the high negative bias is removed from $V_{3B}$ and the control grid is returned through $R_{15}$ (fine delay) and $R_{16}$ to a high positive bias. Since the grid-cathode resistance under this condition is exceedingly small, the grid bias on $V_{3B}$ is essentially zero. The control grid of $V_{3A}$ is returned to ground through the trigger generator output impedance; the bias on this tube is therefore determined by the drop across $R_{13}$. Resistors $R_{13}$ and $R_{14}$ were so selected that under quiescent conditions the plate current of $V_{3B}$ produces sufficient drop across $R_{13}$ to bias $V_{3A}$ well beyond cutoff.

When the output of the trigger generator arrives, the control grid of $V_{3A}$ is brought above cutoff, causing $V_{3A}$ to conduct. The drop in plate voltage of $V_{3A}$ is coupled to the grid of $V_{3B}$ through $C_{11}$ or $C_{12}$ depending upon the selector switch setting, thus driving $V_{3B}$ considerably beyond cutoff.

Since the grid of $V_{3B}$ is returned to B plus through grid-leak resistors $R_{15}$ and $R_{16}$, the grid potential immediately begins to relax exponentially toward this value at a rate determined approximately by the time constant ($C_{11}$ or $C_{12}$) ($R_{15}$ + $R_{16}$). The grid is permitted to relax toward the B plus potential on these two range settings in order that the cutoff potential curve will be intersected at a very steep angle by the grid relaxation curve, thus providing more stable operation on the short delay periods encountered on these ranges.

Coarse delay setting 4 provides essentially the same operation as settings 2 and 3 except that the control is allowed to relax toward the cathode potential instead of B plus.

When the control grid of $V_{3B}$ has relaxed to its cutoff potential, the tube is immediately turned on and $V_{3A}$ is turned off by virtue of the positive feedback obtained through $R_{13}$. The circuit has at this point been returned to its original quiescent condition and remains unchanged until the next trigger pulse arrives.

The plate current flowing through $R_{13}$ in the quiescent condition is of much greater magnitude than the current during the operating period. The drop across $R_{13}$ or the delay multivibrator output (point 4 in Fig. 1 and 2) is therefore a negative rectangular wave. The leading edge coincides with the trigger generator output and the trailing edge with the desired amount of delay, which may be varied from 0 to 2,000 milliseconds by the delay adjustments.

The output of the delay multivibrator is applied to a differentiating circuit and a negative series clipper. When the zero delay position is selected in the delay multivibrator circuits, the input to the differentiating circuit is a positive trigger which charges $C_{13}$ through the parallel path offered by $R_{17}$ and the d-c plate resistance of $V_{5A}$ in series with $R_{18}$. The time constant of this charge path is 7.5 microseconds. Since the input trigger is approximately 15 microseconds in duration, some differentiation occurs, resulting in an output trigger across $R_{18}$ which is somewhat sharper than the input and is slightly reduced in amplitude.

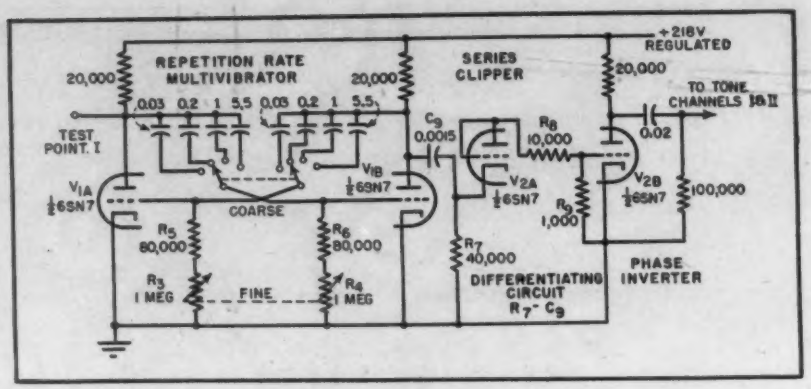



FIG. 3—Trigger generator circuit

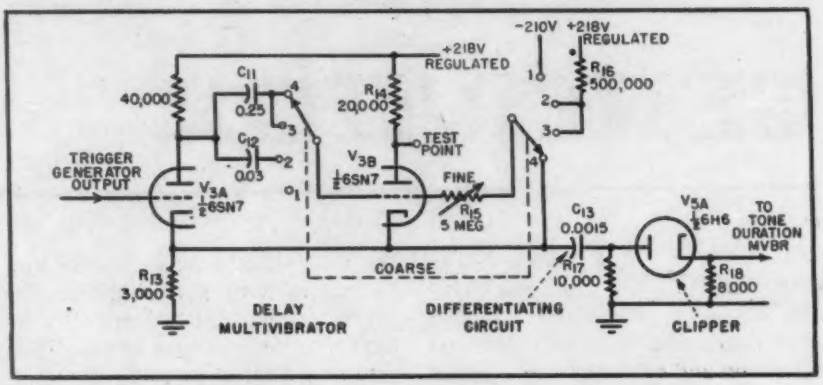



FIG. 4—Circuit of first sections of a tone channel

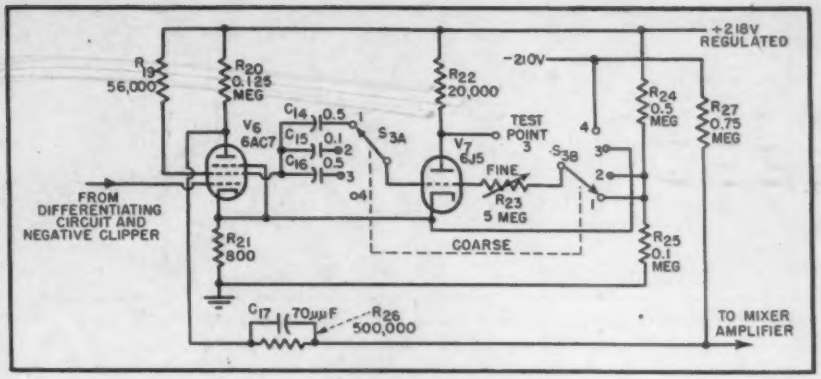



FIG. 5—Tone duration multivibrator circuit for one tone channel

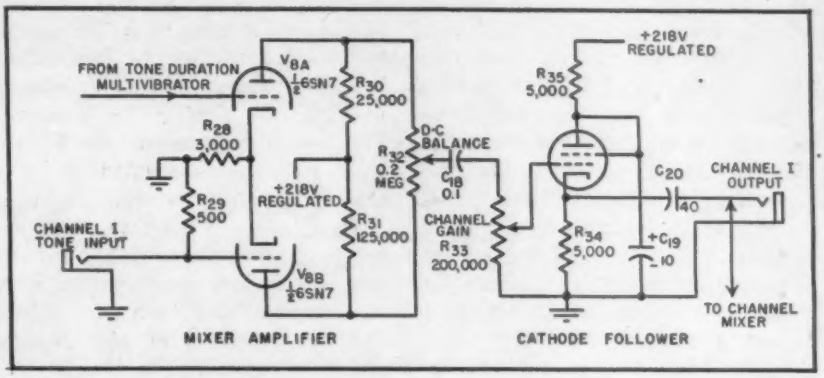



FIG. 6—Mixer amplifier and cathode follower circuits for one tone channel

On the remaining delay settings (2, 3, and 4) the input to the above circuit is a negative rectangular wave. When the leading edge of the wave occurs, the negative drop is coupled through $C_{18}$ to the plate of $V_{8A}$, thus preventing conduction. When the trailing edge occurs, the plate of $V_{8A}$ is driven positively so that $C_{18}$ charges through the parallel path of $R_{27}$ and the $R_p$ of $V_{8A}$ and $R_{28}$ in series. The output of this circuit is therefore a positive trigger which may be delayed from 0 to 2,000 milliseconds depending upon the delay adjustments desired.

The delayed trigger voltage is fed into the single-cycle tone duration multivibrator circuit of Fig. 5. The screen grid, control grid, and cathode of $V_6$ in conjunction with $V_7$ are used to form a conventional triode single-cycle multivibrator. In the quiescent condition, the plate current of $V_7$ flowing through common cathode resistor $R_{21}$ is sufficient to hold $V_6$ well past cutoff. When the delayed trigger arrives, $V_6$ is turned on and $V_7$ turned off by virtue of the feedback obtained through $R_{27}$. When the grid potential of $V_7$ has relaxed to cutoff, $V_7$ is turned on and $V_6$ off so that the original quiescent condition is obtained.

The output of the multivibrator is taken from the plate of $V_6$, which is returned to B plus through $R_{20}$. The tube in the quiescent condition is completely cut off. Since it is turned on when the trigger arrives from the delaying circuits, the plate voltage waveform is that of a negative gate with good leading and trailing edges, a condition necessary to provide satisfactory operation of the mixer amplifier.

The duration of the above waveform is determined by the off period of $V_7$. This period is controllable from 1 to 3,000 milliseconds by means of the fine and coarse duration adjustments $R_{23}$ and $S_3$ respectively. When $S_3$ is in position 4, the grid of $V_7$ is returned to a large negative bias, resulting in continuous conduction of $V_6$. On position 3, the gate width may be varied continuously by $R_{23}$ over the complete range (0 to 3,000 milliseconds). The grid of $V_7$ is permitted to relax toward its cathode potential to provide these long periods.

Switch positions 1 and 2 provide gate widths of from 1 to 75 milliseconds and 3 to 300 milliseconds respectively. On these positions a positive grid bias of 36 volts is provided by voltage divider $R_{24}$-$R_{25}$ so that more stable operation will be obtained. Voltage divider $R_{26}$-$R_{27}$ in conjunction with the −210-volt supply reduces the output potential of the multivibrator during the quiescent condition to +25 volts. When the negative gate is present, the output potential is approximately −135 volts.

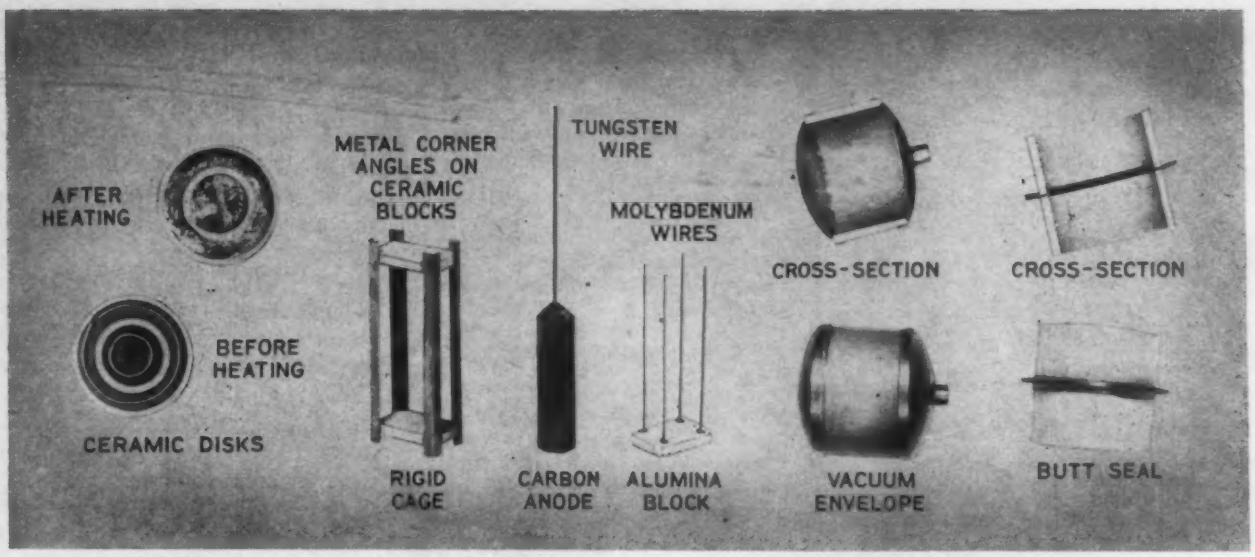
The output of the tone duration multivibrator is applied to the mixer amplifier circuit in Fig. 6, consisting of a 6SN7 twin triode which is used as a combination phase-inverter and mixer.

In addition to the output of the tone duration multivibrator which is applied to the grid of $V_{8A}$, a continuous audio sine wave is applied to the control grid of $V_{8B}$. During the quiescent period of the tone duration multivibrator, the control of $V_{8A}$ is held at +25 volts. Under this condition, the plate current of $V_{8A}$ flowing through common cathode resistor $R_{28}$ develops sufficient voltage drop across this resistor to hold $V_{8B}$ at cutoff. When the input of $V_{8A}$ falls to the lower level (−135 volts), $V_{8A}$ is cut off, thus permitting $V_{8B}$ to function as a class A amplifier.

The plate waveform of $V_{8A}$ is therefore a positive rectangular wave coincident with the input gate, and that of $V_{8B}$ is an inverted (negative) rectangular wave with the amplified sine wave superimposed. These two voltages are applied across potentiometer $R_{32}$. By selecting the output from a tap on $R_{32}$, a point may be obtained at which the two rectangular waveforms exactly cancel, resulting in a gated sine-wave output which is free from any variation in d-c level.

The output of the mixer amplifier is applied to the control grid of a cathode follower through potentiometer $R_{33}$. The cathode follower is employed to provide low-impedance output.

The output of the cathode follower may be obtained directly at the channel I output jack or at the mixed output jack after being mixed in the channel mixer unit




**Typical examples of metal-ceramic metallizing, joining, and sealing as produced by new titanium hydride technique**

# Metal-Ceramic Brazed Seals

**New method involves applying titanium hydride to ceramic, then brazing to metals or similarly prepared ceramics with silver or any other metal that melts at 1,000 C. Resulting seal, gastight and stronger than ceramic itself, is ideal for microwave tubes**

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As the radio-frequency spectrum expanded into the higher-frequency regions, conventional tubes no longer proved satisfactory. Their failure was due largely to the length and impedance of the wires leading through the stem to the tube elements.

One of the qualifications for the successful operation of a high-frequency circuit is that the portion of the circuit represented by the tube must be small in comparison with a wavelength. Disk seal or lighthouse tubes[1] effectively eliminated the lead difficulties and greatly extended the useful frequency range of space-charge-control tubes.

This extension of the operating range into the microwave region imposed new problems in construction. For efficient operation, the tube must be a small part of a wavelength, and preferably a small part of a quarter wavelength. This means that as frequency is increased, the physical size of the tube must be decreased. For a given power rating, a reduction in size can only be accomplished by an increase in the stresses on the component parts and a resultant increase in operating temperature.

At elevated temperatures, the glass portion of the vacuum enclosure is the first to fail. This failure is due to the high dielectric losses in glass at high frequency and to the logarithmic nature of the temperature coefficient of resistance of glass. The effect is cumulative. As the seal runs hotter, its resistance decreases and its loss increases. If the glass does not actually fail by melting, the loading of the circuit caused by the glass loss may limit the performance of the device.

In the case of oscillators, as the glass heats, the oscillations diminish in intensity until an equilibrium is reached. In amplifiers, the high loading caused by a poor dielectric results in low gain.

The sealing of glass to metal requires that the glass be melted to effect wetting. The melting is always accompanied by dimensional changes in the glass. During subsequent annealing and exhaust treatment, the glass may sag and still further alter the geometric accuracy of the tube. This means that glass is not well adapted to the pre-

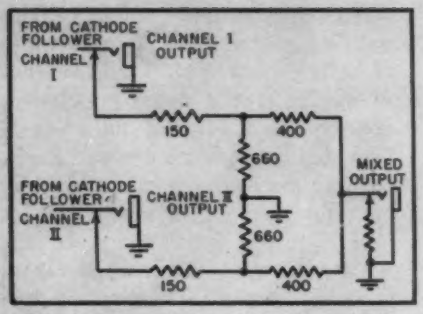



FIG. 7—Channel mixer circuit providing 10 db of isolation between channels

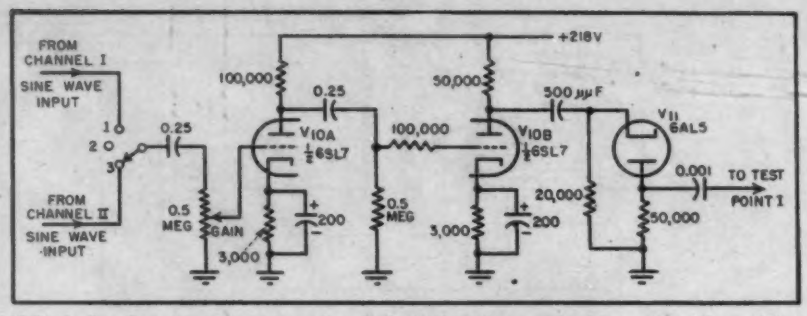



FIG. 8—Synchronizing circuit used to lock in the trigger generator with either of the sine wave oscillators in the tone channels

with the output of channel II. Channel II waveforms are shown in Fig. 2 for points 9 through 13 of Fig. 1.

The channel mixer circuit in Fig. 7 is a parallel T-pad mixer in which 10 decibels of isolation is provided for each channel. The input and output impedances of the mixer unit are approximately 500 ohms. If either channel output is desired without mixing, it may be obtained at the corresponding channel jacks which isolate the mixing unit when a plug is inserted. This prevents the unwanted channel II signal from appearing in the channel I output or vice versa.

The output of the channel mixer therefore consists of the gated tones of channels I and II. Since each of the tones may be delayed from the reference trigger generator output, they may be delayed independently with respect to each other. The duration of either tone may also be independently variable.

### Synchronizing Circuit

The synchronizing circuit which is employed to lock in the repetition rate at some multiple or submultiple of either of the input signal frequencies is shown in Fig. 8. It consists of amplifier stage $V_{10A}$, triode saturation clipper $V_{10B}$, which is overdriven to produce a square wave from the amplified sine wave, a differentiating circuit made up of $C_{25}$ and $R_{28}$ and $R_{29}$ in parallel, and a negative clipper $V_{11}$. The output of the circuit is therefore a negative trigger having a leading edge approximately coincident in time with the zero point of the negative-going portion of the input sine wave.

The trigger is coupled to the plate of $V_{14}$ (Fig. 3) through $C_{26}$ and hence into the grid circuit of $V_{12B}$. During the conduction period of $V_{12B}$, the negative trigger is amplified, inverted, and fed back into the grid circuit of $V_{14}$, where it is superimposed upon the grid relaxation curve and therefore causes the tube to conduct whenever the grid potential is brought above cutoff by one of the superimposed trigger voltages. Selection of the source of synchronization is obtained by means of a switch that in positions 1 and 3 connects the inputs of channels 1 and 2 respectively to the synchronizing circuit. In position 2, nonsynchronous operation is obtained.

### Applications

Perhaps the most useful application of the timing unit for commercial purposes is for simultaneous observation of two related waveforms, such as the input and output voltages of amplifier circuits. The two voltages to be observed are applied to the individual channel inputs, and the output obtained at the mixer jack is applied to the vertical deflection amplifier of a cathode-ray oscilloscope. By synchronizing the repetition rate with the desired reference signal by the method previously described, and synchronizing the horizontal sweep of the oscilloscope with the repetition rate multivibrator output obtained at test point 1, a stationary pattern can readily be obtained. The tone duration and delay controls are then adjusted to separate the two waveforms.

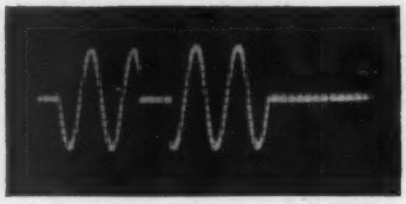


FIG. 9—Example of use of multivibrator keying system as an electronic switch for a cathode-ray oscilloscope, to show the input and output voltage waveforms of an amplifier side by side so that their 90-degree phase difference is clearly evident

To measure the phase shift between the two voltages, the repetition rate is first synchronized with one channel and then the other. The delay control of the channel providing synchronization is adjusted so that each signal is gated at the point at which its positive-going portion crosses the zero reference level. Synchronization is then returned to the reference signal and the amount of delay necessary to return the second signal to its original position gives an accurate measurement of the phase shift between the two signals.

A typical pattern obtained using this procedure is shown in Fig. 9.

The timer may also be used as a square-wave generator. Asymmetrical rectangular waves may be obtained at test points 2, 3, 4, and 5. The degree of asymmetry may be varied by the fine and coarse adjustments located directly above the respective test points on the front panel. Additional rectangular waves may be obtained at the channel output jacks by removing the input signal and adjusting the channel balance controls to give the desired amplitude and polarity. All of these waveforms are quite useful in checking the square-wave response of amplifier circuits.

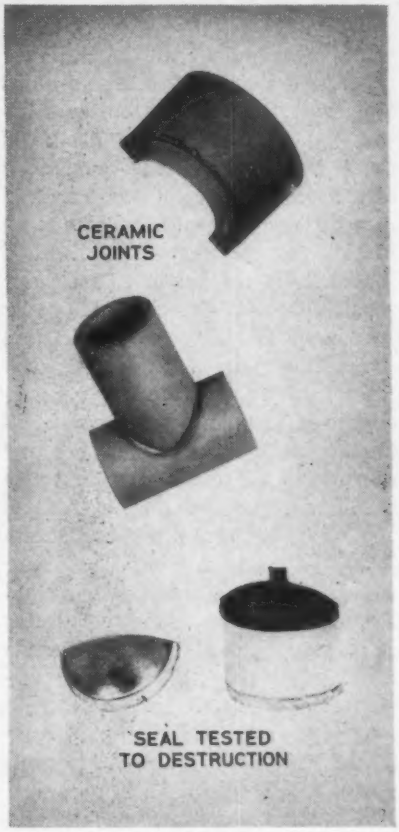
This work was carried out under Task Order No. 1 of Contract N5-ori-166 between the Office of Naval Research and The Johns Hopkins University.

seals, where the bond depends upon an oxide layer on the metal. The removal of excess metal oxides in the vicinity of the glass seal is a constant manufacturing problem.

The freedom from oxides in the ceramic seal results in a bond that resists the attack of strongly reducing atmospheres and metallic vapors. The ability of ceramics to withstand high exhaust temperatures allows the manufacture of tubes capable of being operated under severe conditions without fear of gassing. Test samples have been operated in air at temperatures in excess of 500 C, without signs of gas diffusion or leaks through either the ceramic or the soldered joints.

### Comparison With Other Methods

Other methods of joining metals to ceramics are known and have been used. In one of the most commonly used methods, the ceramic is first metallized in a continuous band around its outer surface. This metallized surface is prepared by coating the ceramic with a paint or paste made from a low-melting point glaze and a salt of gold, silver, or platinum. When this mixture is heated in air to a temperature ranging from 450 to 600 C, the glaze melts and wets the ceramic. The precious metal then floats to the surface of the glaze and forms a continuous conductive layer.




**Examples of ceramic-ceramic and metal-ceramic seals. Particles of ceramic adhere to metal brazing material when tested to destruction, showing seal to be stronger than ceramic itself**

**Table I—Comparison of Ceramic and Glass—Metal Seals**

| Characteristic | Magnesium Silicate (Alsimag No. 243) | Borosilicate Glass (Corning No. 704) |
|---|---|---|
| Dielectric constant (10,000 mc) | 5.5 | 4.6 |
| Power factor (tangent; 10,000 mc) | 0.0002 | 0.005 |
| Loss factor (10,000 mc) | 0.0011 | 0.023 |
| Volume resistance at 300 C | $7 \times 10^{11}$ | $5.17 \times 10^{8}$ |
| Volume resistance at 700 C | $1 \times 10^{8}$ | 1,000 |
| Thermal coefficient of expansion | $10.4 \times 10^{-6}$ | $4.9 \times 10^{-6}$ |
| Softening temperature (C) | 1,440 | 697 |
| Thermal stability | 1,000 | 450 |
| Compressive strength | 85,000 | 70,000 (about) |
| Flexural strength | 20,000 | 8,000 (about) |

Tin or tin-lead solders are used with these precious metal coatings. To prevent the solder from alloying and completely removing the metal band, it is often necessary to cover the metallizing with a protective electrolytic plate. Because of the temperature limitations of soft-soldered joints, they are generally unsuited for most vacuum tube applications.

During the war, the Germans developed and produced a series of ceramic seal triodes for use in the microwave region. The ceramics were prepared for soldering by first coating them with a paint made from finely powdered molybdenum. When heated above 1,300 C in a semireducing atmosphere, the molybdenum adhered to the ceramic. To facilitate subsequent soldering, the molybdenum band was painted with powdered nickel, and then heated in a hydrogen atmosphere to sinter the two metals together. At the final assembly, pure silver would alloy and bond to the nickel surface.

While the ceramic used was not of the extreme low-loss variety, it was better than most glasses and in addition had good mechanical properties.

It is interesting to note that the Germans considered the gains realized by the use of ceramic seals great enough to warrant the use of such cumbersome processing. Their involved methods of joining ceramic and metallic materials are in sharp contrast to the extreme simplicity of the titanium hydride method previously described, where all soldering and bonding is done in one operation.

### Conclusions

The seals and soldering techniques just described were developed primarily for use in the vacuum envelope. However, their many unique properties are well adapted for permanently attaching supports and spacers to tube structures.

Many complicated tube structures, such as are found in cathode-ray tubes, are fabricated by clamping the metal parts to ceramic rods. These mechanical clamps often anneal and become loose during processing. By coating the ceramic rods under the clamps with powdered titanium hydride and powdered copper, and then pre-exhausting the structure in a vacuum furnace at 1,000 C, the parts are rigidly and immovably attached.

Wiring circuits can be permanently attached to ceramic chassis units and subassemblies by printing the circuit on the ceramic part with a paint made from titanium hydride and powdered copper or silver, then firing the metals in place in a suitable atmosphere. Other applications of metallized ceramics will undoubtedly find use in various electrical fields.

### References

(1) E. D. McArthur, Disk-Seal Tubes, Electronics, p 98, Feb. 1945.

cision manufacture demanded by microwave tubes. It is evident that a material possessing better properties is desirable.

### Ceramics for Tubes

A superior material has been found in certain ceramics, especially those of the steatite variety. These magnesium-silicate ceramics, when compared to the glasses now available for vacuum tube construction, not only excel in electrical properties, but have superior physical properties which alone would warrant their use.

A new solution to the problem of obtaining a permanent hermetic bond between the ceramic and metal has also been found. With the newly developed techniques, the ceramic can be joined either to metals or to other ceramics with high-temperature solders. It is of course necessary to match the thermal expansion of the materials in order to avoid residual strains.

The soldering can be done simply by painting the areas of the ceramic with a mixture of powdered titanium hydride in a suitable carrier where it is desired to have the solder adhere. The treated ceramic can then be soldered like any metal part by heating it to a temperature of 900 to 1,000 C either in a vacuum or in extremely pure hydrogen. The solder can be added in the form of rings, washers, or powder as in any conventional soldering operation. Pure silver, eutectic silver-copper alloy, or any metal with a melting point in this temperature range can be used. In areas where the ceramic has been coated with the titanium hydride paint, the solder will spread and firmly adhere.

A suitable paint can be made by mixing 300-mesh titanium hydride powder with an easily volatilized lacquer (such as the nitrocellulose lacquers used in the preparation of heater coatings and emission mixes). The paint is applied to the ceramic in a thin, dense layer either by brushing or spraying.

During the early stages of heating, the titanium hydride dissociates and leaves a residue of pure titanium on the ceramic. The hydrogen evolved during the heating is released in the atomic state and

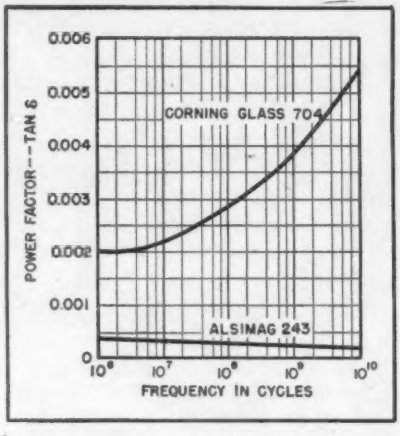
**SIGNIFICANT TREND**

- The metal-ceramic seals and soldering techniques described here constitute a major advance in the design and construction of many well-known uhf and shf tubes
- Ceramic insulators, supports, and windows having higher thermal stability and lower losses than glass are currently limited largely to tubes produced under government contract, but commercial tubes are expected to have these features in the near future
- The technique also offers attractive possibilities for printed electronic circuits and for a host of other applications requiring metallized ceramics as insulators and supports

is more chemically active than hydrogen of the same purity prepared by other means. The presence of this active hydrogen is very beneficial in cleaning the surfaces of the parts. A clean surface is always easily soldered.

Just above the temperature at which the bulk of the hydrogen is released, the silver solder melts and readily alloys with the titanium. This silver-titanium alloy forms a strong bond with the ceramic. In fact, the bond is stronger than the ceramic itself. Destruction tests always reveal a layer of ceramic clinging to the metal.

The fact that the joints can be made in a vacuum is advantageous. When silver and copper are melted in hydrogen, they adsorb large amounts of gas. This gas is later released when the metals are allowed to solidify. The resulting open structure is often a source of




Dielectric loss curves for representative glass and ceramic specimens

very slow leaks. Vacuum soldering eliminates the adsorbed gas problems and yields dense and leak-free metals. Since the parts are heated to 1,000 C in vacuum, they are quite thoroughly degassed. Additional lengthy exhaust treatment is often unnecessary.

### Expansion of Ceramics

The thermal expansion of magnesium silicate ceramic is for all practical purposes linear. Iron containing from 14 to 30 percent chromium has almost identical thermal expansion properties. This combination of materials, when sealed, will remain free from strains over a wide range of temperatures.

To obtain low surface resistance for the radio-frequency currents and to facilitate soldering, a thin layer of copper is alloyed to the chrome-iron. Iron containing a high percentage of chromium is fairly corrosion resistant, and the copper surface further enhances this property. By limiting the surface copper to less than 10 percent of the total thickness, the expansion characteristics of the chrome-iron base are not altered.

Since there are no rapid changes in expansion (such as occur in glass near its softening point), annealing of ceramic seals is unnecessary. They are, however, subject to heat shock and in this respect are similar to glass. High temperature gradients must be avoided. The rate of heating or cooling is dependent upon the uniformity of temperature throughout the ceramic. It is not unusual to take an average size from room temperature to 900 C in three minutes without damage. Because of the very high softening point of the ceramics, parts can be manufactured and soldered with great accuracy and with the assurance that they will not undergo dimensional changes either during sealing or in subsequent exhaust treatment.

### Gassing

Metal parts are free from oxides because the bonding of the metal to the ceramic is done in the absence of oxygen. If the seals are made in vacuum, they are exceptionally free from occluded gases. This is in sharp contrast to the glass-metal

This central signal source supplies modulated frequencies to 25 test stations in a radio receiver manufacturing plant. Coupling, impedance matching, attenuator design, radiation, and leakage are discussed

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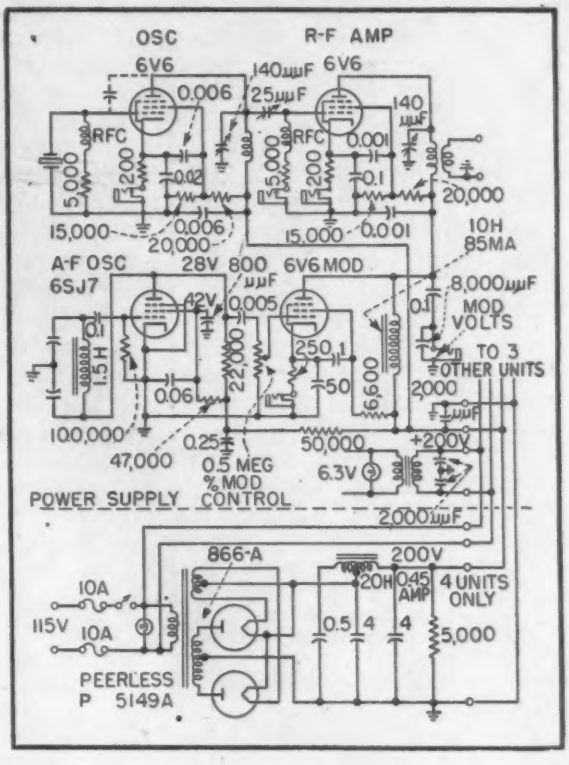



FIG. 1 — Complete circuit of one transmitter and a power supply for four transmitters

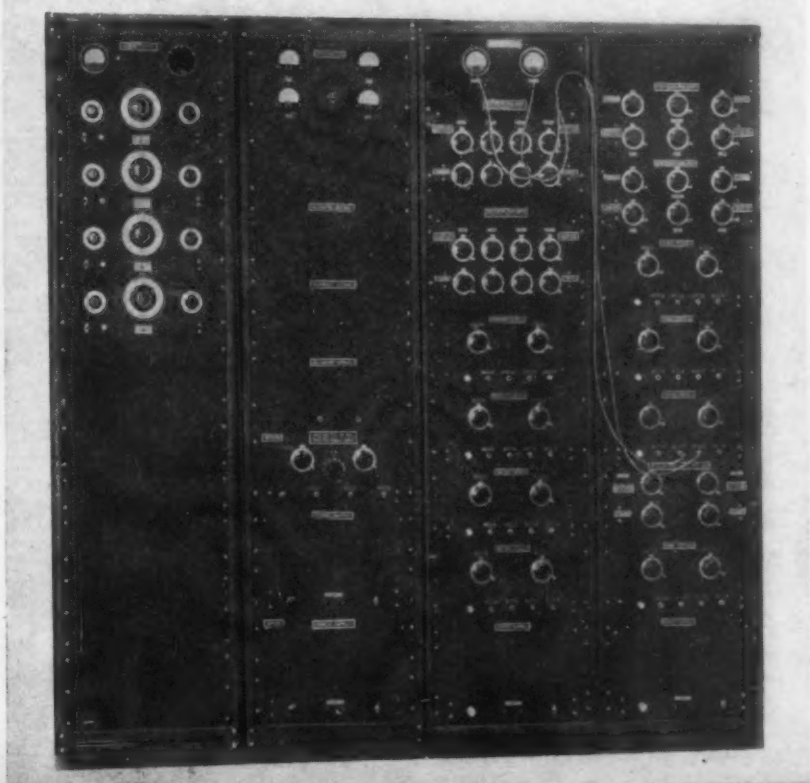
impedance to the other frequencies. This makes it possible to connect such units in parallel to the line, a great advantage as it allows a common ground system and in addition makes impedance matching easy. A series connection would add the impedance of all elements in the circuit at the frequency being considered.

The final impedance match is obtained by adjusting values of a carbon resistor in the resonant circuit. The voltage level is adjusted by a variable capacitor used to vary the coupling to the transmitter. Link coupling is used and the links fed by a 52-ohm coaxial line. The impedance match is not critical at broadcast frequencies, because the line length represents such a small portion of a wavelength; so more attention was given to obtaining the desired voltages at the output of the coupling unit.

The short-wave links are more particular. The inductance of the tuning coil for each frequency is the same as the inductance of the transmitter tank coil for that frequency. The tuning capacitors are also the same value as used in the transmitters. The low impedance of the link circuit requires a large variable capacitance for coupling and a value of 450-$\mu\mu$f served nicely.

One coupling unit is used for each floor (12 stations). Thus, two coupling units are fed from each transmitter. One chassis is used for both i-f units, one chassis per floor (two) for all broadcast frequencies and one chassis per floor (two) for all short waves. Broadcast-band coupling unit is shown in Fig. 3.

Central signal panels contain separate transmitters for each frequency and the coupling units



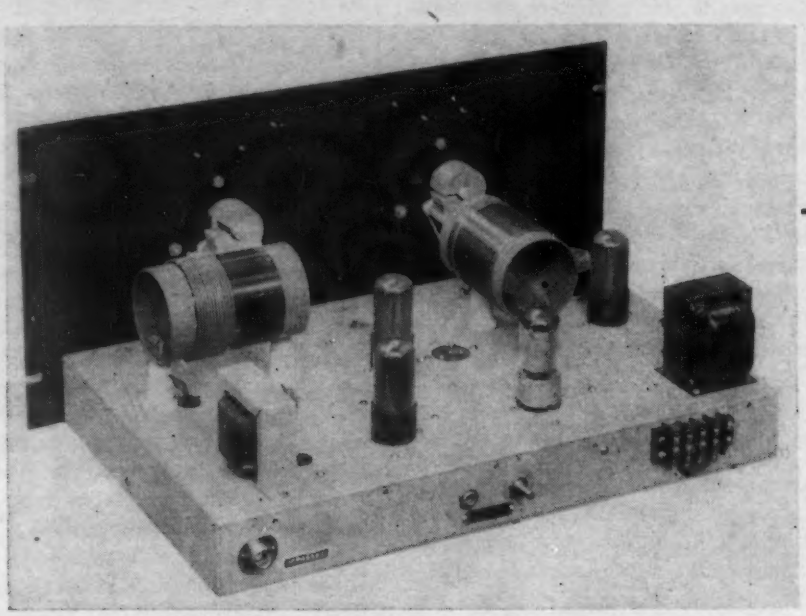
### Transmission Lines and Nets

Four coaxial cables are used for the transmission system. One handles the i-f to eliminate the possibility of beats with other frequencies. One is used for all broadcast frequencies, one for all the short waves, and one for use at a later date for an aligning signal. These cables feed an attenuator box at each test position. The transmission lines are required to carry r-f power from the coupling units to the individual test stations. As power delivery is required at the test stations and a number of frequencies per line are used, it is necessary to match the line im-

# Central Signal Generator for Production Testing

QUANTITY PRODUCTION of radio receivers requires a calibrated source of radio-frequency signals for aligning and testing. This can be supplied by equipment at individual testing stations or by placing the equipment in a central location and using transmission lines to the individual stations. The latter method provides a central location for all the tube equipment, where it can be maintained, adjusted and kept free of tampering by unauthorized personnel. Other factors are cost, uniformity of signals, delivery time, and economy.

The system to be described contains 24 test stations, about 7 feet apart, 12 to a floor (2 floors), with radio-frequency energy covering the intermediate frequency and several spots across the broadcast and short-wave bands. An additional station is provided in the engineering department. The r-f is controlled in amplitude and available in level from 1.0 $\mu$v to 0.1 volt.



Each transmitter chassis contains r-f and a-f stages

### Transmitters

A number of transmitters were built, one for each radio frequency and modulated with an identifying audio frequency. The frequencies chosen are:

| Signal | Frequency | Modulation in cps |
|---|---|---|
| I-F | 455 kc | 1,500 |
| Broadcast | 1,740 | 300 |
| | 1,530 | 600 |
| | 960 | 800 |
| | 610 | 1,000 |
| Short Wave | 6 mc | 2,000 |
| | 10 | 2,500 |
| | 18 | 3,000 |

These radio frequencies were chosen to supply the band limit, alignment points, and cross-over tracking points in each band, missing local broadcast stations. To prevent interruption of service, a spare transmitter unit is provided to replace temporarily any unit needing repair. It is equipped with plug-in coils to cover the radio frequency range and with a rotary switch to select the audio frequencies.

The transmitters employ the circuit shown in Fig. 1. A 6V6 crystal oscillator using an AT-cut crystal is followed by a 6V6 class-C amplifier modulated by a 6V6 Heising modulator. The radio-frequency output is link coupled to a 50-ohm line. Audio signal is supplied to the modulator by a 6SJ7 tube in a Colpitts audio oscillator. This circuit was chosen because only one tube is required, there is no need for a tapped inductance coil, and it permits ease of frequency change and uniformity of transmitters with different audio frequencies.

Panel jacks are provided for reading plate and grid currents and a rear jack for reading modulation voltage. The modulation control is screwdriver adjusted at the rear of the chassis. A meter panel, with a plate current meter and a grid current meter, is used for all units. Standard phone plugs and six-foot cords make connections. A separate power supply is used for each four transmitters, and supplies 200 volts at 0.5 ampere.

Thirty-percent modulation was used at first so that sensitivities measured on the assembly lines would correspond with the standard procedure used in engineering tests. However, the modulation percentage was later raised to about 50 percent to approximate conditions of a broadcast station and resulted in a little clearer signal. The modulation voltage must be maintained constant or the apparent receiver sensitivity will also change.

A coupling unit was required to couple each transmitter of each frequency to the line, keep interaction of frequencies in the transmitters at a minimum, match the impedance of each transmitter to the line, and adjust the voltage level of each frequency on the line. Interaction of controls should be small and the voltage obtainable should be variable from one to several volts. A number of different methods, including cathode followers, were considered but the coupling was accomplished by means of the circuits shown in Fig. 2.

Basically, a series resonant circuit is used for each frequency, as it has the advantage of presenting a low impedance to the particular frequency while presenting a high

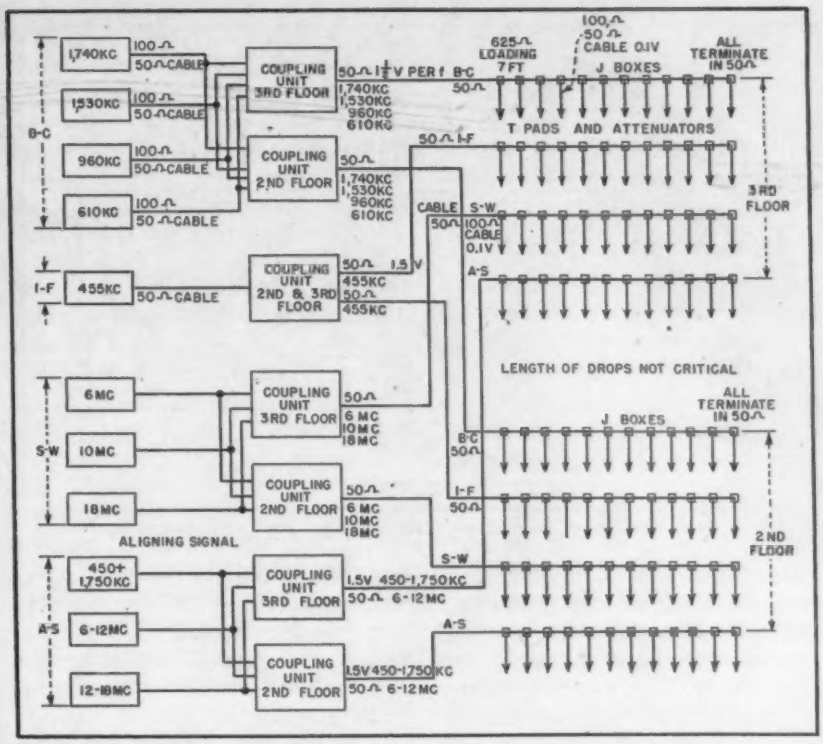



FIG. 4—Arrangement of transmitters, resonant-circuit coupling units, and J-box pads

Attenuators are needed at each test station to reduce the signal level from the maximum available to a known and controlled value. Each test position is equipped with an attenuator box containing a switch for selecting one of the four lines (i-f, b-c, s-w, a-s), four variable T pads for adjusting the level of each line to 0.1 volt; a variable T pad to adjust voltage between steps of the attenuator; and a step, ladder-type attenuator producing output levels in steps of 10 from 10 $\mu$v to 0.1 volt. The four-position switch is arranged to terminate all unused lines in 100 ohms. A test connector is provided for using a vtvm in setting the input level.

It is desirable to purchase attenuators, but due to procurement problems, it was decided to build them. A simple design was required for ease of construction. The attenuator should have a flat attenuation ratio to 20 mc and steps of output voltage of 100,000 $\mu$v, 10,000 $\mu$v, 1,000 $\mu$v, 100 $\mu$v, and 10 $\mu$v. This represents a total voltage attenuation ratio of 10,000 or 80 db. If a very small amount of capacitive coupling exists across the attenuator, the attenuation ratio will change at the high-frequency end of the band to be covered. This would be undesirable as it would cause the attenuation to differ across the band. To reduce this effect the attenuation per stage is kept low (20 db) and each stage individually shielded. To reduce capacitance coupling, the switch was built into the attenuator. This allows the switch contacts to be shielded up to the actual surface of the contact itself and the spacing of contacts reduces the capacitance between them. Capacitance to ground should also be low.

The attenuator elements are formed by carbon resistors. The individual sections consist of a T pad with the series arm 82 ohms and the shunt arm 20 ohms. The circuit is shown in Fig. 6. The design follows that for any simple T pad.

### Variable T Pad

Five variable T pads are used in each attenuator box. One is used on each of the four input lines to adjust the input voltage of the attenuator to exactly 0.1 volt. The voltage along the lines varies due to attenuation along the line and any slight reflections that may be present. The fifth variable T pad is used to control smoothly the voltage between steps of the ladder attenuator. It corresponds to the variable control on a signal generator and enables voltages other than steps of 10 to be obtained. All of these controls are screwdriver types so that the output voltage of the entire attenuator can be set to a value corresponding to the sensitivity of the receiver being tested, thus requiring no adjustment by the operator.

The requirements of this pad are 100-ohm input and output impedance $\pm 10$ percent, a variable attenuation ratio of about 30 db and a reasonably flat frequency response to 20 mc. The variable T pad is made of three rheostats. Two are

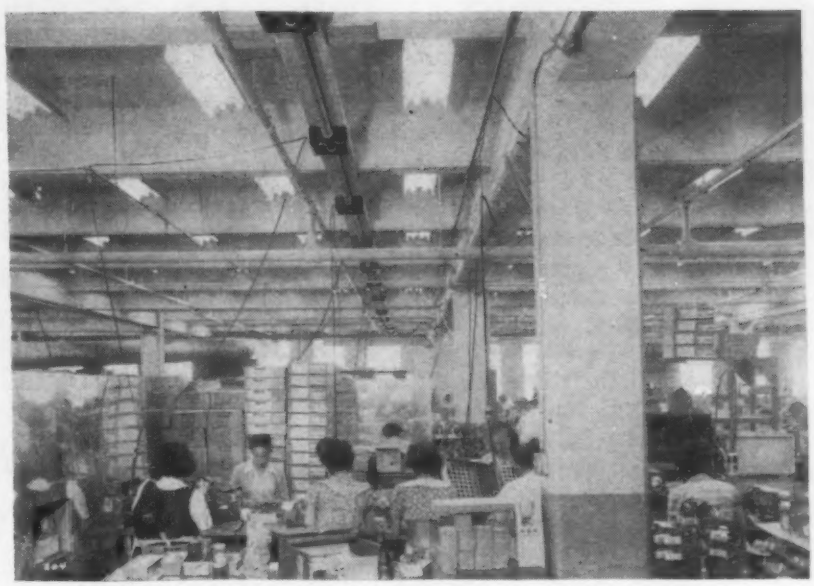


FIG. 5—Conduit and J boxes are mounted on the ceiling of the plant

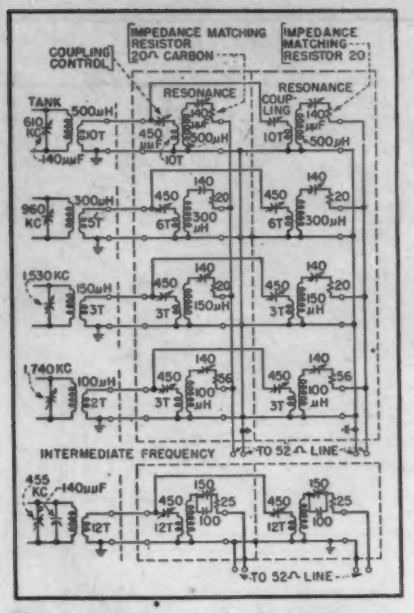



FIG. 2—Coupling circuits for feeding several transmitters to a common line

pedance at the sending and receiving ends.

The effect of mismatch is reflection, which results in standing waves along the line, producing inconsistent voltages at points along the line, frequency discrimination at any one point along the line, and inability to obtain the correct amount of power from the line. As stations are required every seven feet along the line, terminations become quite a problem. This can be seen from the following:

If a 50-ohm line is joined by another 50-ohm line, the impedance presented at the junction is that of two 50-ohm lines in parallel, or 25 ohms. This 25 ohms must match the previous single line of 50 ohms —an impedance ratio of 2 to 1.

As the line progresses another seven feet, another branch occurs with another impedance discontinuity. In addition, the two branches are also looking into 25 ohms, representing an impedance mismatch to the branches. The usual way such a condition is met is by use of transformers to match the different impedances. However, radio-frequency transformers are usually quite frequency selective, and as our lines carry a number of frequencies, transformers could not be used. If a resistive impedance-matching pad was used to match branch impedances, the loss in the number of pads required would be prohibitive.

The method used to accomplish the impedance matching is a combination of line loading and resistive impedance-matching pads. The formula for a distortionless line (one in which theoretically there is no frequency or delay distortion) is $\omega L/R = \omega C/G$, where $L$ is inductance, $C$ is capacitance, $G$ is conductance and $R$ is resistance. This can be written $LG = RC$. Physical lines do not usually approach this relationship, so it is possible to improve the line by loading, usually by increasing the inductance. The $LG$ term may also be increased by increasing the conductance (lowering the leakage resistance across the line) and accepting the attendant greater attenuation.

Our lines use the principle of loading with conductance and then making that conductance the useful load on the line. The conductance used is 625 ohms every seven feet, resulting in an attenuation of six db per hundred feet of cable and changing the characteristic impedance of the cable from 52 to 50 ohms. Because this impedance change is small, it is possible to use unloaded line from the transmitters to the point where loading begins. The lines are terminated in 50 ohms. Figure 4 shows a block diagram of the system.

As the lines are run overhead and the test positions are some distance from the loading points, it is necessary to use another line, dropping from the main cable to the test positions. This line is matched at both sending and receiving ends, but on the longer wavelengths the characteristic impedance of the line itself is not matched. This was done to be able to use a more convenient and cheaper cable. The receiving end is terminated in the attenuator box, and the sending end is matched by an impedance-matching T pad.

The line loading is 625 ohms and power is taken off in this loading. The input impedance of the impedance-matching T pad is 625 ohms and used for the conductive loading, and the output impedance made to look like 100 ohms to feed the branch line. Minimum attenuation is required to reduce loss as much as possible. To meet this condition, one series arm of the pad is made zero. An unusual feature of this pad is that the input looks like 625 ohms to the line, but the line looks like only 50 ohms to the pad. The output looks like 100 ohms and also is terminated in 100 ohms. The pad was designed to have an attenuation of 20 db or a voltage ratio of 10 to 1.

These pads are contained in J boxes which in turn are placed in a larger box every seven feet along the line. Figure 5 pictures the installation of the lines on one floor of the building and shows the conduit, J boxes, T-pad J boxes, cable drop offs, and shielded booths.

FIG. 3—Coupling unit for standard broadcast frequencies

from the outside ground conductor of the cable acting as an antenna because of a slight potential difference between the outside coaxial conductor and the transmitter ground plane. As it is difficult to determine the actual point of equal potential (the ground plane), indeed if such a point exists, and because any connection to this point must be of extremely low r-f impedance at 20 mc, it is very difficult to control this type of radiation by a simple ground connection to the transmitter frame. A special filter was constructed by soldering a few feet of the outside coaxial conductor to a metal plate in an S shape and then grounding the plate. This filter is quite effective, but placing the cable in conduit is a much better answer.

If any appreciable signal is present on the main lines, it can radiate from them, as well as be conducted along them, and cause a very difficult control problem. This is prevented by the use of filters.

Simple r-f filters are used at the transmitter units. They consist of 0.002-$\mu$f mica capacitors from B+ to ground and from both sides of the main line to ground. These are installed where the wiring enters the chassis, and the lead lengths are kept to less than one-half inch. It was found unnecessary to use filters in the main power wiring to the power supplies. Filters in the shielded booths contribute to this control, as well as reduce noise from the countless number of fluorescent lights and machinery. These filters are installed, one in each main wire, and contained in a metal box which is grounded to the booth metal wall.

### Low-Frequency Padding

In production aligning of radio receivers, part of the procedure may be accomplished more rapidly, and perhaps better, with inexperienced personnel, by the use of a wide-band signal. This allows trimmers to be tuned for maximum output without rocking the gang.

A number of disadvantages of the multivibrator for this use became apparent. One of the most glaring is the fall-off of radio-frequency voltage with frequency directly as the order of the harmonic. To maintain proper distribution of the harmonics, the fundamental frequency of the multivibrator should be in the audio range, say, 1,000 cps. If coverage is required to 20 mc, the output voltage falls to 1/20,000th of the fundamental and an amplifier to build this characteristic up to a flat curve and furnish an output level of about five volts to operate the system is a big order.

It was decided to use a radio-frequency oscillator sweeping across the band at an audio rate. A motor-driven capacitor was chosen for the sweep. During sweeping, the signal would appear on a receiver only a few microseconds every 1/100th of a second, and to increase the length of time the signal passed the receiver frequency, frequency modulation was added by means of a reactance tube. When the circuit was tested, f-m was found to be unnecessary, and it was also found that the motor speed could be reduced to 1,800 rpm, which results in an impulse every 1/30th of a second.

Coupling units represent a somewhat different problem from the other units, as they must handle a band of frequencies. Cathode followers were chosen for this reason. They were designed to work into a 50-ohm load, and two followers were used, one for each floor.

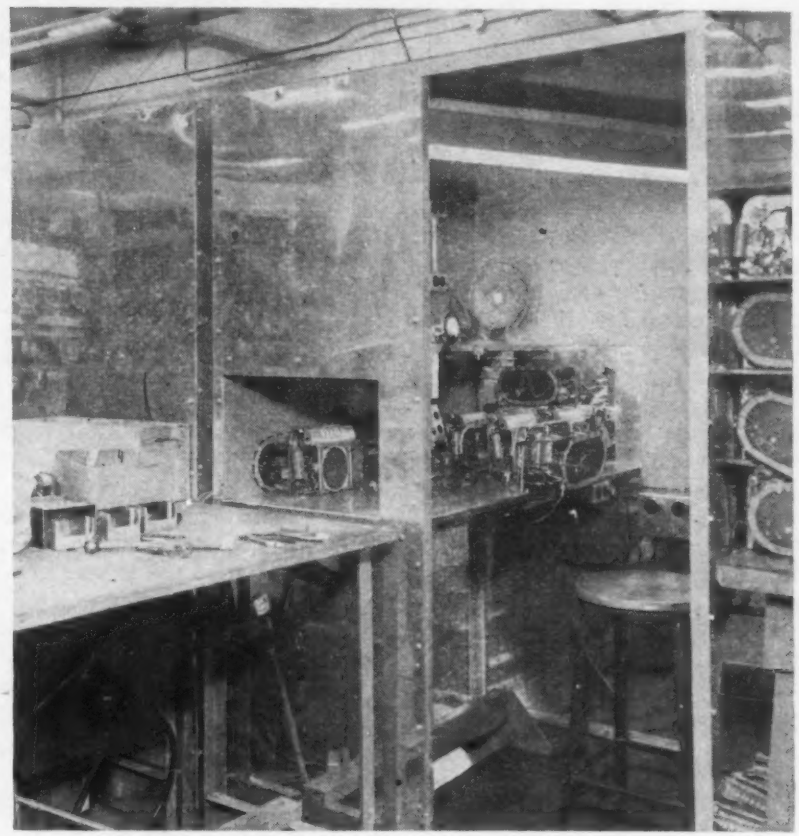


FIG. 7—Shielded booth contains openings for passing through receiver chassis

### Additional Equipment

Since the equipment was first installed, some of the features added are padding signals, an audio system, additional test stations, changing location of test stations including one in the engineering department with an additional 50 feet of line, and split test stations. The latter consists in feeding part of the four cables of a station to another station, for example, taking the i-f signal to another test position to enable another test operator to prealign the i-f stages. Thus production can be increased on an assembly line by the use of two test operators. A feature being added is a monitor system to check the r-f signal level on all lines.

Test operators report that they like the system, that it is much easier for them and results in faster testing.

linear taper 100-ohm maximum value, clockwise rotation; one is log taper (curve A) 1000-ohm maximum value, counterclockwise rotation. Rheostats for radio frequency are difficult to obtain, so a number of tests were made and it was found that a wire-wound control possessed considerable inductance, and that a high-resistance control showed a capacitive effect. A low-resistance carbon-type control is as capacitive as a high-resistance one, but the capacitive reactance is shunted by a low resistance and becomes less important. Controls made of molded composition were quite satisfactory in the 100-ohm value tested.

The output of the attenuator may be wired directly to the receiver antenna terminal, using a dummy antenna, or it may be coupled to the receiver loop, using another loop as a radiator. The loop method is favored, as it allows a greater production speed because no connections are made to the receiver. A loop was designed, keeping the distributed capacitance low, to have an impedance of 100 ohms in the middle of the broadcast band. This loop worked very satisfactorily for the i-f and short waves as well. The receiver i-f response was naturally considerably less than the other frequencies due to no front-end gain in the receiver and is in fact a desirable discrimination.

### Radiation and Leakage

In a system comprising a number of watts of transmitter power and a large network of transmission lines, the problem is present of radiated radio-frequency energy getting to the receivers to be tested. This energy, arriving around or bypassing the regular system, causes trouble in a number of ways. Radiated signals are generally undesirable because of the possibility of causing local interference in nearby broadcast receivers, heterodyne whistles (in our case occuring only on very distant stations because of choice of signal frequencies), and in the case of the i-f frequency, heterodyne whistles on every signal tuned in.

More serious is the by-passing of the attenuator, thus causing the attenuation ratio to change, particularly on the 1 to 10 microvolt levels.

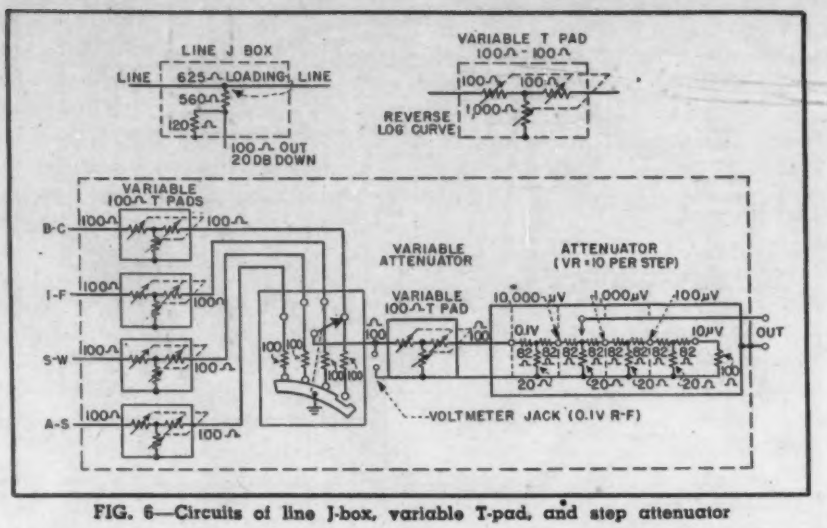



FIG. 6—Circuits of line J-box, variable T-pad, and step attenuator

The problem can be divided into two main classifications: radiation, and leakage. The difference between these may not be apparent, so we will define leakage as local effects, such as leakage across an attenuator due to capacitive or inductive coupling, and radiation as energy arriving through the medium of space. Its field may be considerably distorted inside a building. Conduction along the main lines is included as leakage.

Radiation occurs mainly from the transmitter and associated equipment due to the large amount of power present there. It may also occur from long runs of unshielded coaxial lines. It was decided to attempt to control direct radiation by shielding each unit and, after the equipment was placed in operation, determine if it was necessary to add further controls, such as a shielded room. It was decided that with other controls used the equipment need not be placed in a shielded room and that even the shield cans may be left off to facilitate tube or other maintenance.

When unshielded loops are used to couple power to receivers under test, the large number of loops used contribute a field strength which may be higher than the residue radiation from the transmitters. It would be uneconomical to reduce radiation from the transmitters to a point greatly lower than that from the loops. No attempt has been made to shield loops used in the open on the assembly lines, although this might be done by placing the receiver in an open metal box. Shielded booths are used at test positions where sensitive receivers are aligned. These reduce radio noise disturbances from automatic screwdriver motors, fluorescent lights, and eliminate any residue signal leakage that may be present.

### Shielding Detail

One shielded booth is shown in Fig. 7. The booths are made of aluminum alloy sheets on an extruded angle frame. When all openings are closed, no broadcast stations can be received, but the booth is normally operated with no door and two openings for handling receivers. The receivers slide on a steel-topped bench equipped with a wooden insert under the coils of the receiver being tested. An 80-db line filter is installed. It is important that this filter and also the attenuator box be mounted directly on the booth metal wall to obtain a good ground. A wire or braid to ground is not sufficient. A Celotex lining improves the acoustical characteristics.

The greatest control of radiation by any single item was installing all coaxial cables in conduit. A completely closed conduit system (except for drop-off cables) was used, tying the whole system together with a common ground to the transmitter cabinets. It is unimportant whether this system is grounded to actual ground. The conduit also controlled coaxial cable radiation. This radiation occurred, not so much through the cable, but

# PHOTOELECTRIC PHOTOMETER

**Designed for laboratory tests on smoke filters, the equipment can be adapted to many industrial problems. The amount of light scattered by smoke is picked up at right angles to the main beam and measured by a phototube and d-c amplifier**

instrument depends on the stray light, which is reduced to a minimum by buffing the trade mark from the lamp, using coated lenses which are kept free of surface dust, and utilizing a carefully-designed system of baffles and a V-shaped light trap in the base of the cell. The inside of the cell is covered with optical black paper. The slits before the phototube prevent it from seeing the illuminated edges of the baffles as shown. The total stray light, originally $1.5 \times 10^{-7}$ lumen, was reduced to $1.0 \times 10^{-7}$ lumen by coating the cell and baffles with soot from burning camphor.

It has been found that the vacuum phototube must be chosen for its stability and linear response. The S-4 surface, used in the type 929 and 935 tubes, is the one most sensitive to light from a tungsten source at a color temperature of 2,870 K. The 935, designed to minimize leakage currents which may limit the light sensitivity, was not readily available but removal of the 929 tube base, coating the tube with high-resistance ceresin wax, and soldering connections directly to the leads, increased the resistance from between $10^{9}$ and $10^{11}$ ohms to $10^{13}$ or $10^{15}$ ohms. The debased 929 tube, mounted inside a sealed case as shown in Fig. 3, was employed with complete satisfaction.

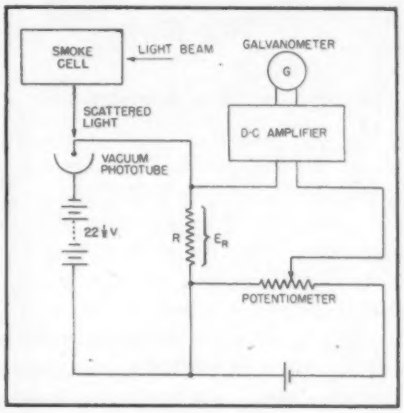



**FIG. 1—Simplified diagram of the penetrometer, showing how intensity of scattered light is effectively measured by a potentiometer and a scaling resistor *R***

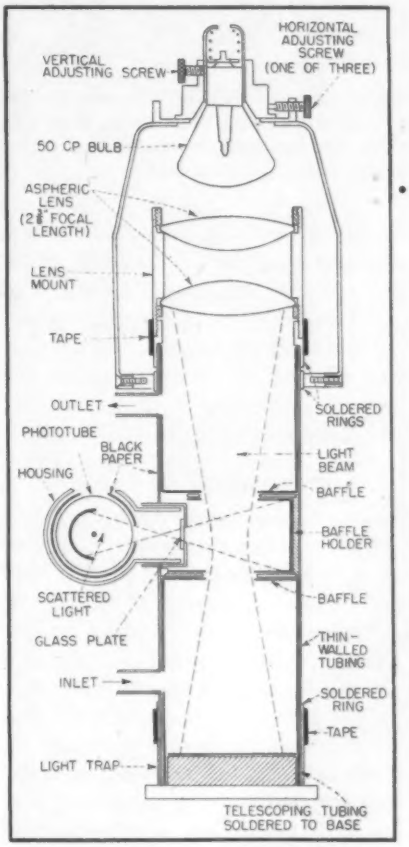



**FIG. 2—Detail of the smoke cell, showing the light source and mounting of the phototube that gathers reflected light from smoke particles**

### D-C Amplifier

A single-stage d-c amplifier with a rugged taut-suspension pointer-type galvanometer in the balanced plate circuit, has the advantage of simplicity and stability, but requires very high resistors in the phototube circuit and an amplifier tube of correspondingly high input impedance. The characteristics of a number of tubes were studied, and the 38, 1C7G, and 1D7G were all found suitable for this purpose. The type 38 was used because of its availability.

About a third of the tubes tested could be operated at grid currents of $-2$ to $-8 \times 10^{-13}$ ampere, by making the grid sufficiently negative, reducing the heater voltage, and keeping the maximum inter-electrode potential below 15 volts, the ionizing potential of the residual gas. It was also found that the grid current-grid voltage curve of this tube could be shifted along the current axis by changing the heater-cathode potential. Internal leakage probably causes this effect, which varies somewhat from tube to tube, and may be turned to advantage in choosing operating conditions.

Another suitable d-c amplifier tube is the acorn-type 954. Its use in circuits with resistances up to $10^{11}$ ohms has been described[3] and might allow an improvement in the sensitivity of the instrument.

The amplifier tube was mounted in a desiccated airtight box, next to the phototube, battery and scale

# SENSITIVE

By FRANK T. GUCKER, Jr.
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External view of the photoelectric photometer, or penetrometer. Smoke manifold is at the left

IMPROVEMENT in smoke filters used in Service respirators required development of a rapid and simple testing apparatus of extreme sensitivity. The same method now can be used in testing commercial smoke and dust respirators and in the scientific study of aerosols, colloidal materials dispersed in air. Aerosols made from dispersed liquids, with particles about 0.3 micron in diameter, provide the severest test of a filter.

A suitable uniform test smoke can be produced by saturating a stream of air with the vapor of a stable high-boiling liquid like dioctyl phthalate (DOP) in a heated vessel, then suddenly quenching the vapor with a stream of cold air. The test smoke must be very dilute —about 100 micrograms per liter— or it changes rapidly by coagulation and also tends to clog the filter. Smokes of this dilution are barely visible.

Fortunately, photoelectric optical methods can solve the problem, provided the test smoke is homogeneous. The amount of light scattered from such a smoke in the well-known Tyndall beam in a small cell is proportional to its concentration considerably above 100 micrograms per liter. However, the light scattered from a particular mass of smoke depends upon the size of the particles it contains. When an inhomogeneous smoke is passed through a filter, the particles of different size are removed with different efficiencies, hence the size distribution changes. In this case the relative light-scattering of the initial and filtered smokes is not a quantitative measure of their relative concentrations. This fact must be clearly understood in considering optical methods of measuring smoke-filter efficiency.

Tolman and Vliet[1] have described a Tyndallmeter for visual photometric measurement of the light scattered at right angles from the beam. The present instrument, called a penetrometer because it was designed to measure smoke penetration through filters, employs photoelectric measurement. It was developed in the author's laboratory by Chester T. O'Konski and Dr. Hugh B. Pickard. An overall description has been published elsewhere.[2] Photoelectric and electronic details are given here.

### Experimental Arrangement

A schematic view of the apparatus is shown in Fig. 1. Light scattered in the smoke cell at right angles to the Tyndall light beam falls on the phototube. The resulting photocurrent, passing through a high resistor $R$, produces a potential drop $E_R$ which is measured by the potentiometer, using a d-c amplifier and null-point indicator. The response of the vacuum phototube is proportional to the light falling upon it, hence the potentiometer can be calibrated directly in terms of scattered light intensity or smoke concentration. As the smoke concentration decreases from $10^{-4}$ to $10^{-8}$ gram per liter, $R$ is increased in decimal steps from $10^7$ to $10^{11}$ ohms, thus maintaining the potential drop within a range which can be measured conveniently.

The whole apparatus is housed in a metal $12 \times 20$-inch cabinet 12 inches high, as illustrated. The gas cocks at the end of the cabinet, fastened together in pairs, lead to the raw smoke, filtered smoke, and filtered air lines. All are shown closed, bypassing the smoke cell. When the top handle is turned perpendicular to the side of the cabinet, connection is made through the cell.

### Smoke Cell

The smoke cell is shown in Fig. 2. All metal parts are brass, silver-soldered where necessary to make strong joints. The 50-candlepower automobile headlight bulb is adjusted to focus a light beam in the center of the cell. The light scattered at right angles to the axis of the beam passes through two rectangular collimating slits to fall on the phototube.

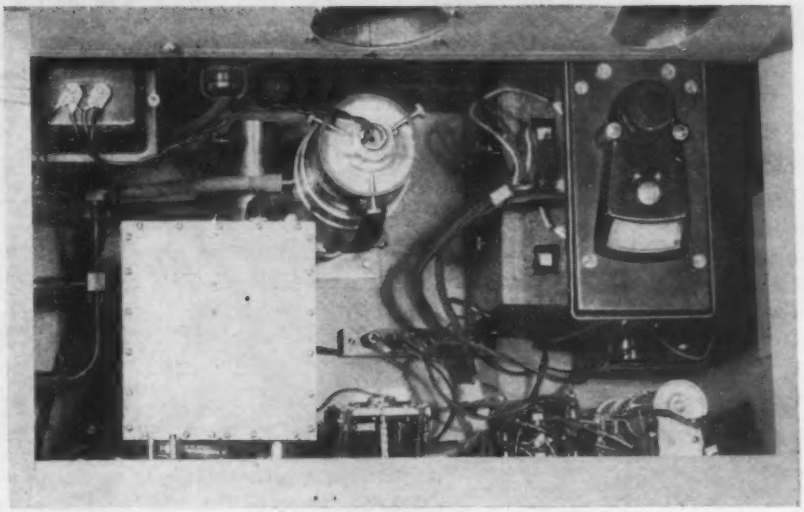
The limit of sensitivity of the

This paper is based upon work done for the Office of Scientific Research and Development under Contract OEMsr-282 with Northwestern University.

stray light controls. This adjustment is checked every half hour.

Next, the smoke cell is filled with the raw test smoke, the scale switch is turned to 1, the percent penetration dials to 100, and the sensitivity controls are adjusted to balance the amplifier. About 0.25 v is required to balance the light scattered from a DOP smoke of 0.3 micron diameter, at 100 micrograms per liter. For much more concentrated smokes, the range of the penetrometer is extended by applying 3.0 v to the potentiometer, and balancing the stray light and smoke currents as before.

The penetrometer now reads 100 percent penetration for the raw test smoke. When filtered smoke is put into the cell, the scale switch turned to the proper point, and the amplifier balanced by adjusting the percent penetration dials, the reading gives immediately the light scattering, relative to that of the raw smoke. Thus a reading of 34 percent on the 0.001 scale corresponds to 0.034 percent of the original scattered light, and a filter penetration of 0.034 percent, if the test smoke is uniform.



Inside the penetrometer. The smoke cell is center rear, battery box under the galvanometer. The sealed amplifier box appears left front, with a window for viewing desiccant material on top

The validity of the measurement of low filter penetrations with this penetrometer cannot be checked directly by gravimetric measurements. However, the self-consistency of a series of measurements can be checked by means of the well-established law of filtration of homogeneous smokes: the fractional penetration of such a smoke through a filter is independent of the smoke concentration. Thus if a composite pad is made of a series of $n$ similar sheets of filter material,* the fractional penetration of each of which is $P_1$, the fractional penetration of the whole pad will be

$$P = P_1^n \text{ or } \log P = n \log P_1.$$

A plot of $P$ against $n$ on semi-logarithmic paper therefore should give a straight line. Two series of

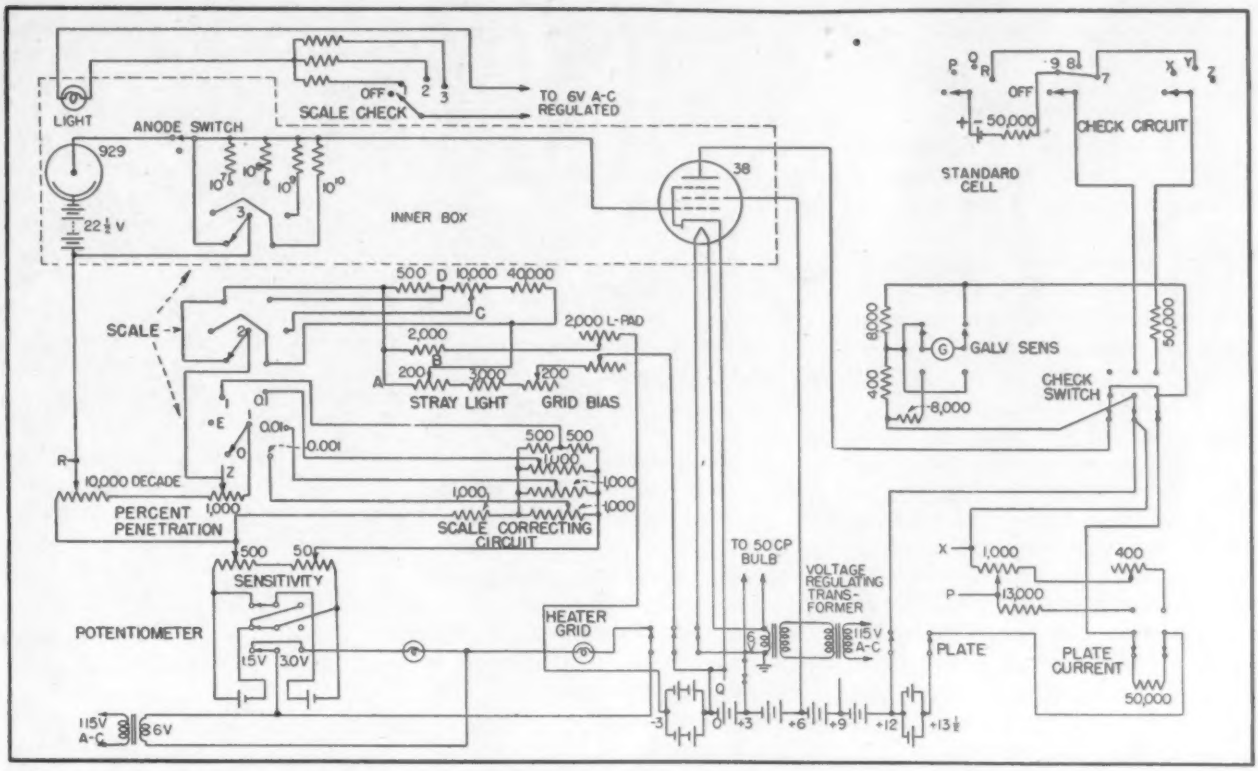



FIG. 4—Schematic circuit diagram of phototube and amplifier circuits. Voltage checking circuit for batteries has been simplified

switch carrying the high resistors. A rubber bulb, inflated when the box was closed, reduced the tendency for breathing of humid air due to temperature change.

The wiring diagram of the apparatus is shown in Fig. 4. A potential checking circuit has been simplified for clarity. The plate-circuit galvanometer has a resistance of 1,000 ohms, and sensitivity of 0.125 microampere per millimeter. A double-pole double-throw pushbutton switch controls its sensitivity. Pushing the button connects the galvanometer across an 8,000-ohm damping resistor, giving high sensitivity. Releasing the button returns the switch to its normal position and reduces the galvanometer sensitivity by a factor of 20. When the galvanometer is balanced, a plate current of 30 to 32 microamperes across the 50,000-ohm resistor balances the potential of the last section of the plate battery (1.5 to 1.6 v).

The measurement of minute photocurrents requires correction or compensation for the following parasitics in the grid circuit: phototube leakage current of about $10^{-13}$ ampere; amplifier grid current of $-10^{-11}$ ampere or less; stray light current of about $5 \times 10^{-12}$ ampere. In this apparatus, these are all compensated by the stray light control, connected to the second gang of the scale switch. First, this switch is turned to 0, disconnecting the potentiometer and connecting the point *A* directly to the grid of the tube. The grid bias L-pad and 200-ohm resistor are adjusted to balance the galvanometer in the plate circuit. Next, the scale switch is turned to *E* (check), connecting the highest ($10^{10}$ ohm) resistor to the photocell. The smoke cell is swept out with filtered air, and the potential drop due to the parasitic currents is balanced by moving the stray light potentiometer *B* to the right. When the scale switch is turned to the $10^9$-ohm resistor, the 10,000-ohm potentiometer *C* is adjusted to maintain compensation on the 0.01 scale.

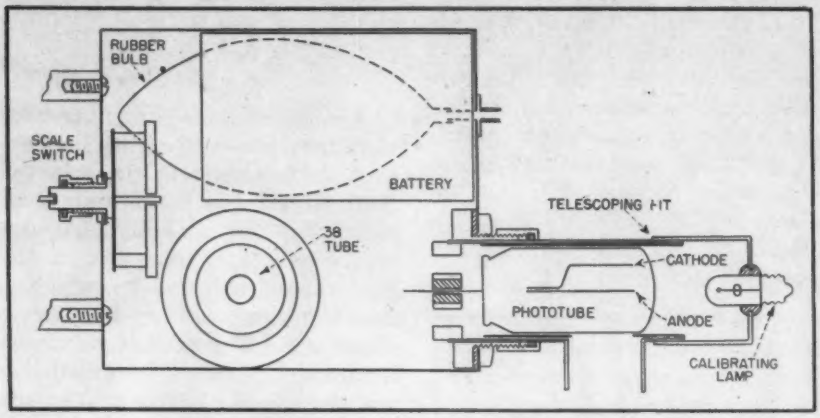



**FIG. 3—Plan view of sealed amplifier and phototube housing. Calibrating lamp at the right is used to adjust the equipment. The rubber bulb is inflated to reduce inhalation of moisture with changes in atmospheric pressure**

The connection to *D* gives correct compensation on the 0.1 scale, while none is required on the 1 scale. The compensation is adequately independent of subsequent changes of the grid bias controls, since the total variation in the resistance of this circuit cannot exceed 3 percent.

### Potentiometer Scale-Corrector

The voltage range of the two-dial percent penetration potentiometer is regulated by the sensitivity controls. The range of photocurrent measurement is determined by the position of the scale switch, the third gang of which holds four metallized resistors, nominally $10^7$, $10^8$, $10^9$, and $10^{10}$ ohms, mounted on a ceramic wafer. In order to make the instrument direct-reading, the successive resistors must differ by factors of exactly ten, or deviations must be compensated automatically. Since even selected resistors may differ by 10 percent from their nominal value, a simple compensating circuit connected to the first gang of the scale switch varies the emf applied to the potentiometer, in proportion to the deviations of the resistors on the different scales. The scale-correcting circuit allows the potential on the 0.1, 0.01, and 0.001 scales to be varied by $\pm 12.5$ percent of that applied to the 1 scale.

The scale-correcting potentiometers are adjusted, by means of three slotted shafts on the left-hand side of the front panel until the readings of a constant photocurrent differs by a factor of exactly 10 on two successive scales. A suitable current is produced in the phototube by means of the calibrating lamp shown in the phototube housing (Fig. 3). The light is controlled by the resistors connected to the scale check switch. Thus, to compare the 1 and 0.1 scales, the percent penetration dials are set at 10 on the 1 scale, and the scale check switch is turned to 1. Then the emf due to the steady photocurrent is balanced with the sensitivity controls. Next the dials are set at 100 on the 0.1 scale, and if necessary the amplifier is balanced by a screwdriver adjustment of the top scale-correction potentiometer. This makes the 1 and 0.1 scales consistent, and similar adjustments bring the others into harmony. In practice, the high resistors do not have to be checked frequently, although the whole process takes only a few minutes. This arrangement can be used to give the advantage of direct reading to any circuit employing a series of high resistors.

### Filter-Penetration Measurements

Before making any measurements of smoke penetration, the heater-grid switch is turned on and the tube allowed to warm up for a half hour. With the scale switch on 0, the plate switch is turned on, and the amplifier is balanced with the grid bias controls. The smoke cell is flushed out with scrupulously filtered air, the potentiometer switch turned to 1.5 v and the scale switch to *E*. Then the parasitic currents are balanced with the

# Clipping and Clamping CIRCUITS

**By NORMAN W. MATHER**
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**Performance characteristics of basic circuits for removing that portion of a signal which exceeds a predetermined level or for passing only signals exceeding the clip level, and for restoring or changing average values of signals having level portions**

CLIPPING or leveling circuits are used to perform many useful operations, such as creating square waves from sine waves, removing large noise pulses from audio-frequency signals, and removing portions of signals for special purposes.

Clipping circuits may be arranged either to remove the portion of a signal which exceeds the clip level or to pass only those signals which exceed the clip level. Some of the circuits can be modified so that the signal is clipped only a portion of the time, or so the signal is eliminated except when it arrives at the proper time.

Clamping circuits, also called d-c restorers, are used to restore or change the average value of signals which have level portions in their waveforms. The level portions of the waveforms are necessary if the clamping action is to be accomplished. Signals having random variation (or low-frequency a-c components) which are passed through a-c amplifiers usually have the low-frequency components badly distorted. Clamping circuits act to restore these components, and also to change the d-c level of the signal if desired, by periodically clamping a level portion of the signal waveform at a specified voltage.

### Shunt Diode Clipping

The simple clipping circuit in Fig. 1A uses a diode in shunt with the path of the signal. Circuits of this type can be used only when the load on the circuit is small compared to the load imposed by the diode when it conducts.

This type of circuit clips or levels the signal whenever the plate voltage of the diode becomes positive because its resistance is then much smaller than that of the series resistor, so that a large voltage drop occurs in the series resistor. When the plate voltage is negative, however, the diode is essentially an open circuit and the voltage drop in the series resistor is small. Reversing anode and cathode connections gives positive output pulses.

Copper-oxide, selenium, or crystal rectifiers can be used in place of diodes, depending upon the characteristics of the signal and the circuit in which the clipping circuit is placed. Due to their large shunt capacitance, large dry-disk rectifiers are unsuitable when the signal has high-frequency components.

Application of an adjustable voltage to the cathode as in Fig. 1B makes it possible to set the voltage at which the input signal is clipped. The opposite portion of the signal can be clipped by reversing the diode. The diode and potentiometer resistance must be much smaller than the series resistance.

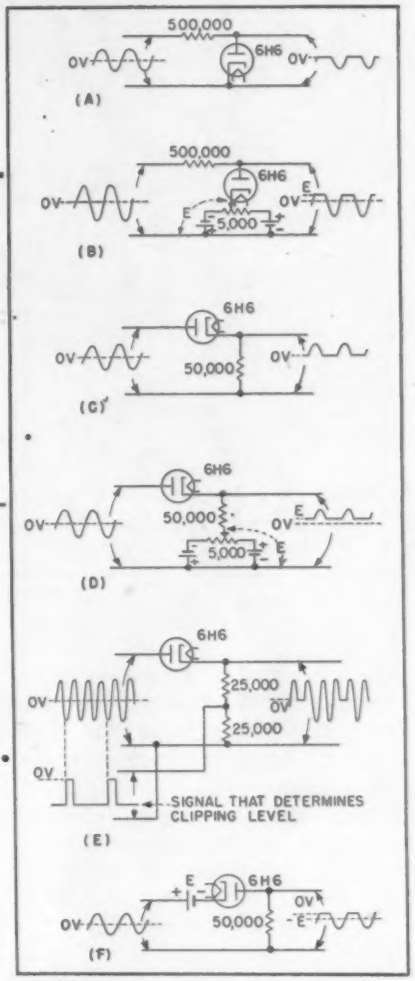


**FIG. 1—Basic series and shunt diode clipping circuits**

### Series Diode Clipping

With a diode in series with the path of the signal as in Fig. 1C, the circuit can be loaded more heavily than when using a shunt diode. The values of the circuit elements are not critical insofar as the clipping action is concerned but depend upon

results with one of our meters, shown in Fig. 5, are seen to follow the filtration law over a 250-fold change in concentration. These results check the validity of the penetrometer and also the homogeneity of the test smoke. A curve concave upwards indicates an inhomogeneous smoke, the larger particles of which are removed by the first few sheets.

### Smoke Currents

Smoke currents may be measured directly. The percent penetration potentiometer is adjusted to read in centivolts on the 1 scale by setting the dials on 101.8, connecting the check circuit to position 7, and balancing the galvanometer with the sensitivity controls. Changing back to the usual measuring circuit, the parasitic currents are compensated as before, and the amplifier balanced with smoke in the cell. The dial setting gives the smoke current in millimicroamperes ($10^{-9}$ amp)

The penetrometer may be calibrated directly in micrograms per liter of any particular smoke by measuring the concentration of a sample (by collecting and weighing the smoke in a known volume), setting the percent penetration dials to correspond, and adjusting the sensitivity dials to balance the amplifier.

### Parasitic Currents

The potentiometer is adjusted to read in centivolts, its dials brought to zero and the scale switch set on 0.001. Then the top of the smoke cell is covered with a light-tight cap, and the amplifier balanced with the grid bias controls to compensate grid and leakage currents. The cell is flushed with filtered air, the cap is removed, and the amplifier balanced with the potentiometer dials, the reading of which gives the stray-light current in micromicroamperes ($10^{-12}$ amp). To measure the amplifier grid current, opposite in sign from the stray-light current, the potentiometer is calibrated in centivolts, the anode switch is opened to eliminate phototube leakage and dark currents, the stray light potentiometer is turned to 0, and the amplifier balanced on the 0.001 scale, using the grid bias controls. The grid voltage includes the

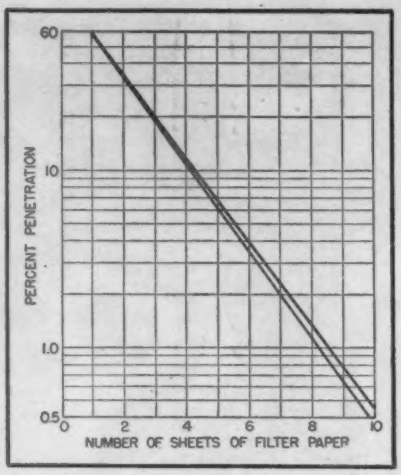


FIG. 5—Validity checks of the test smoke and the phototube method. Penetration through a filter decreases as the number of sheets of filter paper is increased

*IR* drop of the grid current, which is eliminated by turning the scale switch to 1. To rebalance the amplifier, the percent penetration potentiometer must be adjusted, and its reading corresponds to the negative grid current, in micromicroamperes.

If the anode switch is closed and the smoke cell is capped, the procedure of the preceding paragraph measures the amplifier grid current (0 to $-10^{-11}$ amp) plus the phototube leakage and dark currents (about $10^{-12}$ amp), which are found by difference.

The selection of a tube with sufficiently low grid current and the choice of operating conditions, requires a knowledge of the amplifier-tube characteristics, which can be determined without any auxiliary equipment as follows:

The anode switch is opened and the potentiometer calibrated in centivolts. Connecting the check circuit in position 8 opposes the grid voltage with the standard cell and potentiometer voltages in series. The grid bias then can be set on any desired value between $-1.02$ and $-2.5$ v, and the corresponding grid current measured as described in the preceding section.

Turning the plate current switch to its upward position connects a 1,000-ohm potentiometer and 400-ohm rheostat across the 1.5-v auxiliary plate battery. The measured value of the 13,000-ohm resistor and the voltage from the 1,000-ohm potentiometer required to balance the galvanometer allow the plate current to be calculated. It is simpler to make the potentiometer dial read directly in plate current, as follows: The check circuit in position 9 opposes the standard cell and 1,000-ohm potentiometer, which must be adjusted to 1.018 v to balance the galvanometer. The plate current required to give this potential drop across a resistor, for example of 13,420 ohms, would be $1.018/13{,}420 = 76 \times 10^{-6}$ amp. After setting the potentiometer dial at 76 and balancing the galvanometer with the 400-ohm variable resistor the potentiometer scale reads directly in microamperes, within a few percent.

### Other Applications

The instrument here described can be applied to many other measurements beside that of smoke-filter penetration. It could be used to measure the amount of dust in flue gas, and hence determine the completeness of combustion in steam plants. It would be useful in checking the loss of fluid catalyst used in petroleum cracking, by measuring the amount in the exit gas from the regenerating units. It could be applied to the measurement of atmospheric dust and smoke contamination and to the testing of filtered air in any chemical or biological manufacturing process where dust and bacterial contamination must be prevented. Replacing the smoke cell with a cell designed for liquids would give an extremely sensitive nephelometer, with which to study the concentrations of liquid colloidal systems. The use of phototubes with different response characteristics, suitable light filters, and polaroid disks would allow the convenient measurement of many optical properties of aerosols, suspensoids, or emulsoids. The sensitive photometric circuits here developed could be applied to a study of the intensities of spectral lines, fluorescence, and Raman spectra.

### References

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(2) Frank T. Gucker, Jr., Hugh B. Pickard, and Chester T. O'Konski, *J. Am. Chem. Soc.*, **69**, p 429, 1947.
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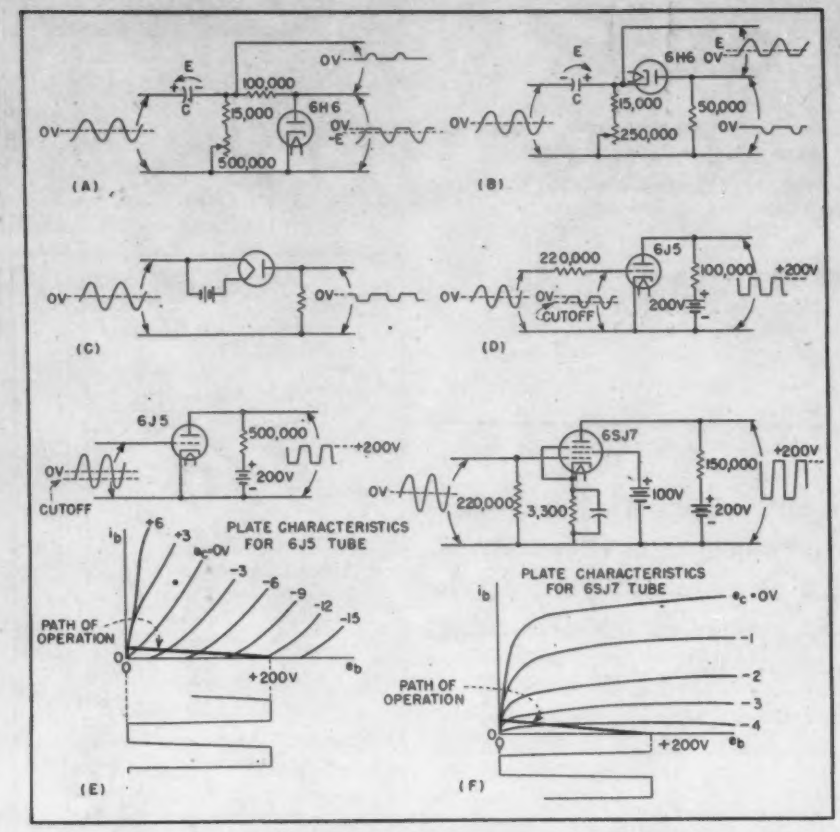



FIG. 2—Special clipping circuits, including arrangements for grid and plate clipping

the application. The diode passes the signal whenever the instantaneous flow of current is in the direction which tends to make the diode plate positive. The signal is clipped when the plate voltage becomes negative. Reversing polarity of diode connections gives negative output pulses.

In the series diode circuit of Fig. 1D the clipping level is set by adjustment of the variable potentiometer. In the circuit of Fig. 1E, the clipping level is determined by a voltage wave applied from an external source. The circuit of Fig. 1F uses a series battery to change the average level of the signal and thus change the clipping level.

#### Series Capacitor for Bias

Circuits with adjustable clipping levels, in which the average value of the signal is changed by the d-c voltage developed across a series capacitor, appear in Fig. 2A and 2B. This voltage is developed due to the difference of the charging and discharging time constants of the circuit, which includes the capacitor and the diode. The ratio of these time constants can be changed by means of the variable resistance in the circuit, thus changing the voltage across the capacitor and the clipping level. The clipping level also depends upon the average amplitude of the signal, hence these circuits cannot be used with irregular waveforms.

#### Emission-Saturation Clipping

A clipping circuit which depends upon the emission saturation of a tungsten-filament tube is given in Fig. 2C. Clipping in this circuit occurs when the plate voltage is negative or when the emission limit of the filament is reached. The resistance shown in the circuit represents the load. Tungsten-filament tubes are not commonly available in small sizes; however, the type FP-400 can be used.

#### Grid and Plate Clipping

With grid circuit clipping as in Fig. 2D, the positive portions of the grid signal are clipped in the same way that signals are clipped in the diode circuits of Fig. 1. The signal is amplified, inverted, and the opposite portion of the signal is clipped if the grid signal becomes negative enough to cause plate current cutoff. A bias voltage may be applied in the grid circuit to change the clipping level.

Clipping in the plate circuit due to plate-current cutoff at one extreme and to space-charge limitation of plate current at the other extreme is utilized in Fig. 2E. The signal is amplified and inverted as well as clipped. A large load resistance is used in the plate circuit so that the path of operation on the plate characteristic will be as indicated. The flow of grid current in this circuit loads the circuit supplying the signal, which therefore must have a low internal impedance.

Clipping in the plate circuit of a pentode, illustrated in Fig. 2F, is similar to the action of the triode circuit of Fig. 2E except that the grid is not driven positive and thus the loading of the signal source is eliminated. The signal must not be too large and sufficient cathode bias must be used for proper operation.

#### Cathode-Circuit Clipping

When clipping in a cathode-follower circuit as in Fig. 3A, the top of the input signal is clipped when grid current flows due to the voltage drop in the resistor in series with the grid. The bottom of the signal is clipped when the grid-to-cathode voltage becomes negative enough to cut off plate current. A relatively large input signal is required if both the top and bottom of the input wave are to be clipped. A potentiometer across the cathode resistor adjusts the average value of the input signal and controls the grid bias voltage.

Clipping in the cathode-input amplifier of Fig. 3B occurs when grid current flows and when plate current is cut off. This circuit requires a low-impedance signal source (such as the output of a cathode follower). It has the advantage of giving voltage amplification and clipping without inverting the signal.

#### Coincidence Circuit

The signals in Fig. 3C are clipped except when they coincide. Either of the control grids can cut off plate current, and both are biased beyond cutoff in this circuit. When

they are both raised above their cut-off potentials, plate current flows and an output signal is obtained. Similar effects can be obtained with ordinary triodes and pentodes by applying one of the signals to the cathode, screen grid, or suppressor grid.

#### VR and Thyrite Clippers

Neon lamps or VR tubes can be used in the gas diode type of clipping circuit shown in Fig. 3D. The resistor is chosen so that the current conducted by the tubes stays within their ratings. The output voltage has small spikes on the leading edges because the gas tubes require a starting voltage which is greater than their normal voltage drop while conducting.

A clipping circuit using a Thyrite element appears in Fig. 3E. Thyrite devices are often used on power transmission lines to minimize voltage surges due to lightning.

#### Diode Clamping Circuits

In the diode clamping circuit of Fig. 4A, the upper portion of the input signal is clamped at zero voltage. By reversing the diode the opposite side of the signal can be clamped at zero voltage. Operation depends upon the difference in time constant for charging and discharging $C$. When charging, the diode resistance shunts $R$, but while discharging the diode acts as an open circuit. Selenium, copper-oxide, or crystal rectifiers can be used in place of the diode.

A clamping circuit with an adjustable clamping level is given in Fig. 4B. By placing the diode in a circuit containing an adjustable d-c voltage $E$, the clamping level assumes the voltage $E$ instead of zero level. The opposite side of the signal can be clamped by reversing the diode.

#### Triode Clamping Circuits

Clamping in the grid circuit of a tube as in Fig. 4C involves action of the grid circuit of a tube similar to diode action, hence clamping can be obtained by using the grid in place of the plate of the diode. This operation is merely a special case of grid-leak biasing.

If neither top nor bottom of the wave to be clamped has a suitable level portion, clamping can be accomplished with the synchronized clamping circuit of Fig. 4D if some intermediate portion of the wave is level. Signals which occur at random about such a level portion will cause the signal to have a varying average value as indicated by the dotted line on the input waveform. If the signal has passed through stages having a-c coupling only, these low-frequency components become out of phase with the main signal or are lost entirely. The purpose of the clamping circuit is to restore the signal to its original form.

The switching voltage is synchronized with the signal so that the tubes, which are normally biased beyond plate-current cutoff, are switched on when the portion of the signal to be clamped occurs. The tubes then conduct and cause the output to have the proper value during the clamping period. The coupling capacitor assumes a charge during this period which results in the random signal starting at the right level. Before the capacitor voltage has had time to stray far from the proper value, the circuit again clamps and the capacitor voltage is brought back to the proper value.

Synchronized clamping can also be accomplished by using diodes in place of the triode tubes of Fig. 4D. Instead of a battery or other steady voltage source, switching signals are applied to the cathode of one diode and to the anode of the other. During the time that these two signals have the same voltage, clamping occurs at this voltage, but when the cathode signal is made more positive and the anode signal is made more negative than this voltage, the circuit is free to follow the main signal voltage.

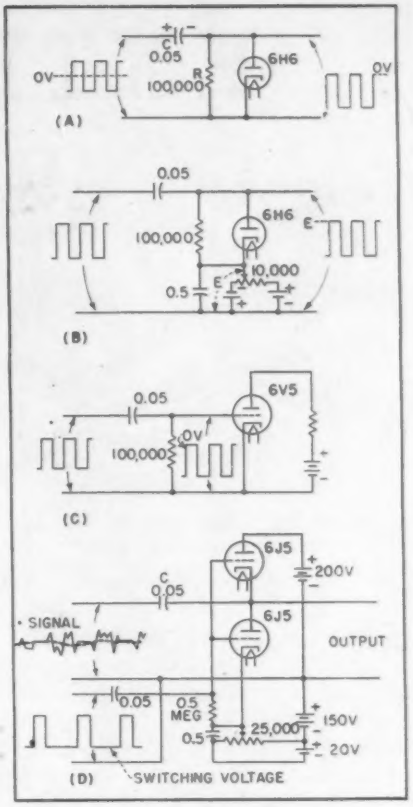



FIG. 4—Diode and triode clamping circuits, also called d-c restorers

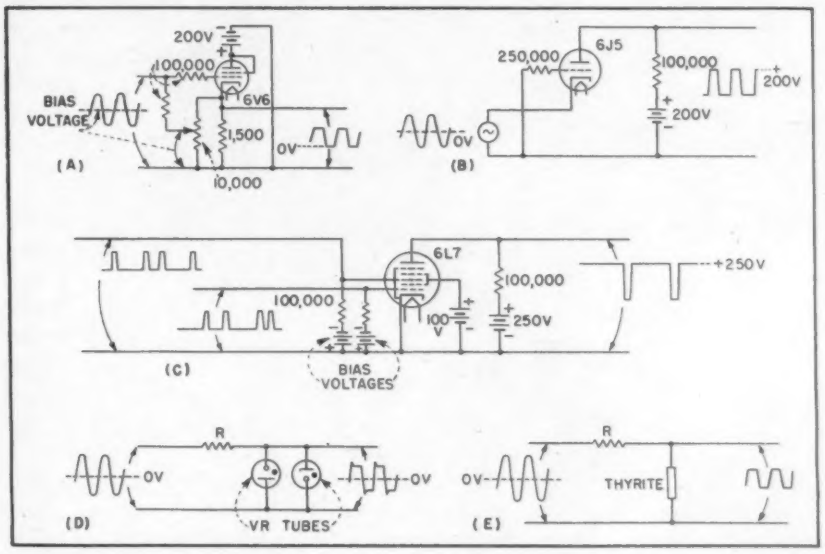
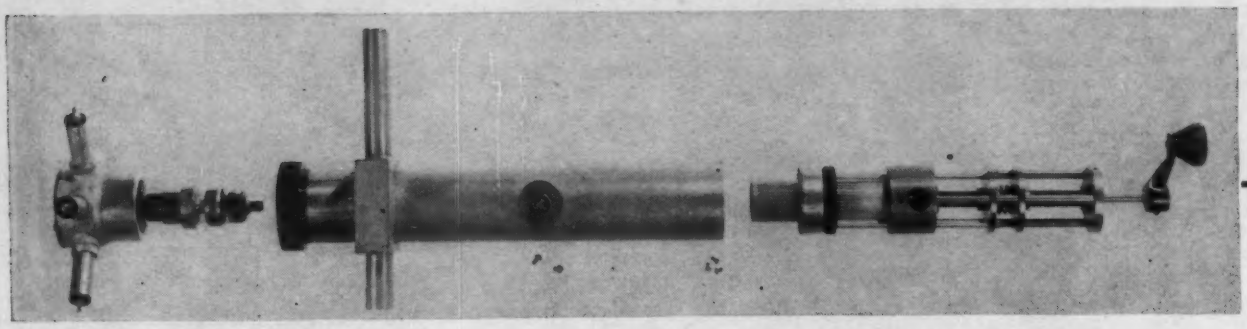



FIG. 3—Examples of cathode-circuit clipping, a coincidence circuit that clips except when two input signals coincide, and special gas diode and Thyrite clipping circuits

# EXTERNAL CAVITY



Exploded view shows specially designed fingers on contacting plunger of coaxial cavity of Aircraft Radio Corp. for full octave coverage with 6BL6 klystron. Most of the power measurements referred to in text were made using this cavity

MOST MICROWAVE DEVICES, especially tubes for local oscillators whose action depends upon electron bunching, operate over a relatively narrow frequency range. Ordinarily this condition is taken as a matter of fact, because equipment is generally intended for use at a single frequency. There are, however, uses in which a microwave local oscillator operable over a wide band is highly desirable. The type 6BL6 reflex klystron, when associated with a suitable cavity resonator, is such an oscillator.

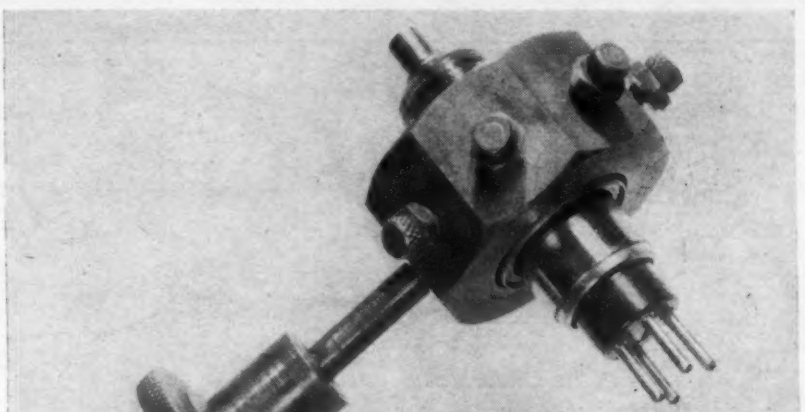
### Klystron Development

During the war a reflex tube (type SD835) with external cavity was developed as illustrated in Fig. 1 for the armed forces. It became evident that this tube was interesting as a general instrument and after the tube was declassified work was continued in cooperation with Wright Field, Airborne Instruments Laboratory and Aircraft Radio Corporation, one of the primary objectives being a further increase in operating bandwidth. RMA type number 6BL6 was assigned to the tube shown as Fig. 2. Electrical characteristics of the tube are summarized in Table I.

Overall length of the tube is approximately three inches, and the largest diameter is one inch. Base pins, which fit a standard four-pin cable-connector, provide connections to heater coil, cathode, and beam-modulating electrode (normally operated at cathode potential). A miniature top cap provides connection to the reflector electrode. The heater coil is insulated from the cathode in order to avoid modulation of signal output by heater-voltage variation in applications where such modulation would be serious. Power input to the tube is of the order of 14 watts of which approximately 4.5 watts is heater power. As may be seen from Fig. 3, power output is between 100 and 150 mw. at an efficiency of about 1.5 percent.

A microwave oscillator that is easily tuned over a broad frequency band, is dependable and rugged, and in which tube replacement is easy, requires a tube having an external demountable cavity resonator. Type 6BL6 was so designed. Its disk seal structure makes possible small physical dimensions, ruggedness without too much difficulty in manufacture, good power dissipation capabilities, and ease of tube replacement without need of scrapping expensive plumbing each time a tube is changed.

The disk seals consist simply of thin copper sheets extending through the glass wall of the tube. These copper disks are backed up by being spun over metal rings to achieve mechanical strength and are



Seven individually adjusted tuning plungers in this toroidal cavity of Sylvania Electric Products for use with the external cavity klystron cover from 3.75 to 4.60 kmc

# KLYSTRON

**Ten centimeter klystron for use with a separate cavity can be tuned over a full octave covering the range from 7 to 14 cm in single-mode operation and giving about 100 milliwatts output. Development and characteristics of this tube and tunable cavities for use with it are described**

By PAUL G. BOHLKE and FRANCIS G. BREEDEN

*Research Department*
*Sylvania Electric Products, Inc.*
*Bayside, New York*

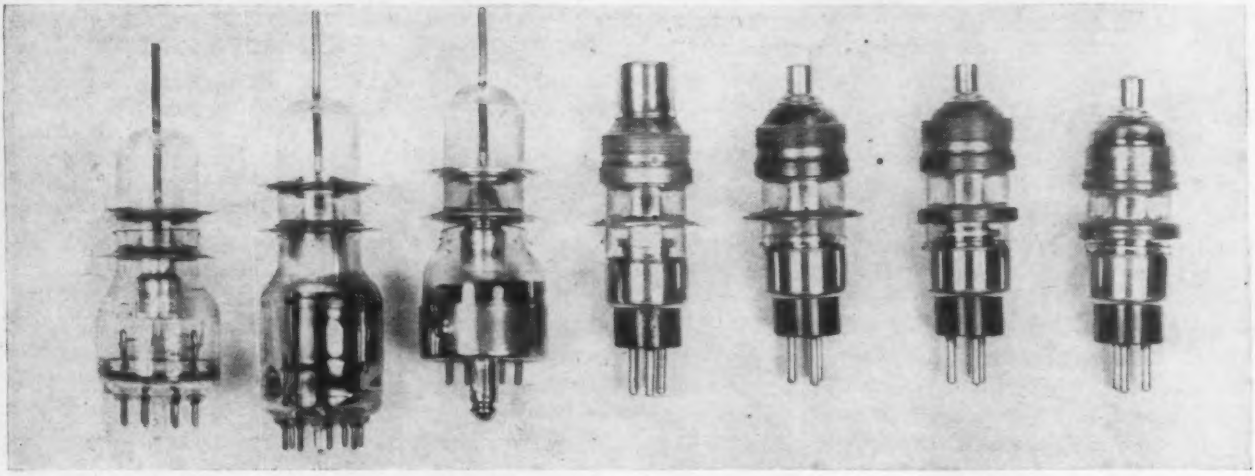


**FIG. 1—Development of wide range, external cavity klystrons**

gold plated to provide protection against corrosion. Diameters of the two resulting disk-cylinders are such that in the single operation of plugging a tube into the coaxial cavity, contact is established to both conductors.

The depth to which the tube can be inserted into the cavity is controlled by squaring the end of the smaller disk and holding its length to specified dimensions. If a shoulder is provided inside the center cavity conductor, tube insertion depth will be controlled by contact between this shoulder and the end of the disk. Thus in a given cavity replacement tubes will always be inserted a uniform amount. Electrical contact to the small disk is made by means of spring fingers which slide over the chamfered edge of the cylinder when the tube is inserted as in Fig. 4. Proper design and machining of these fingers, together with the shoulder stop described above, provide uniform contact for any replacement tube in a given cavity. Electrical contact is made to the lower disk by a toroidal spring held in a retaining groove in the outer cavity wall and which presses firmly against the cylinder. Spring pressure on the cylinder is readily adjusted by selection of wire size and pitch of the helix which is formed into a toroid. Using such a spring contact allows compact cavity design and small volume inside the system when tuned for highest frequency operation in a given cavity mode.

Although type 6BL6 tube is designed for use in coaxial types of cavities, it can be used to good advantage in other cavities for applications where wide tuning range is not necessary. A toroidal cavity tuned by means of radially adjustable screw plugs, will operate well with the toroidal spring contact system applied to both disks.

In the coaxial cavity arrangement of Fig. 4, the reflector voltage lead necessarily comes through inside the center conductor of the cavity, requiring good insulation. As far as the tube is concerned, insulation is achieved by the long leakage path over glass between the top cap and the smaller disk-cylinder and by using a top cap whose diameter is small compared to the inner diameter of the center cavity conductor.

### Matching Tube to Cavity

Use of some of the earlier tube types disclosed a number of interesting factors which received considerable study; these included: (1) the frequency range for the $2\frac{3}{4}$ mode (Mode numbers are desig-

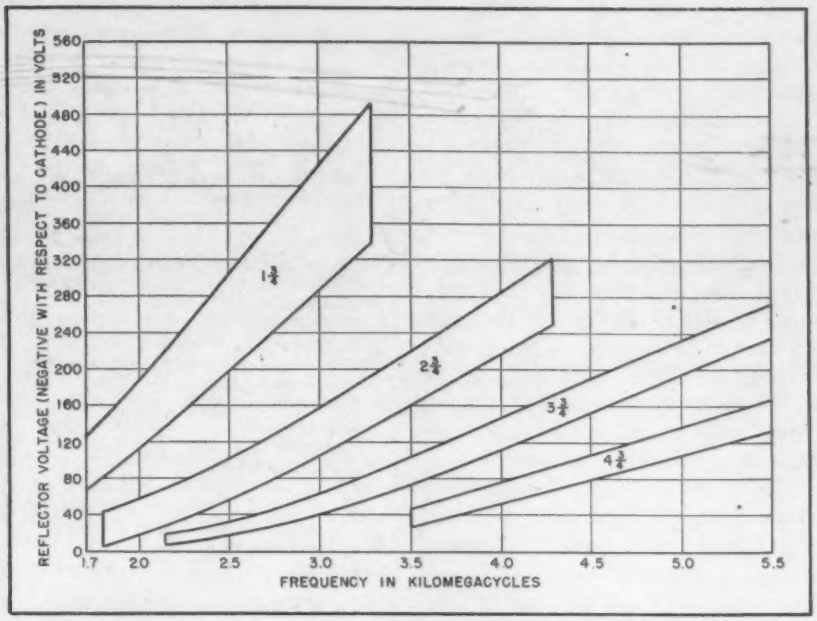



**FIG. 6—Reflector mode characteristics. These characteristics are simplified to show only the tube modes omitting a multiplicity of cavity modes**

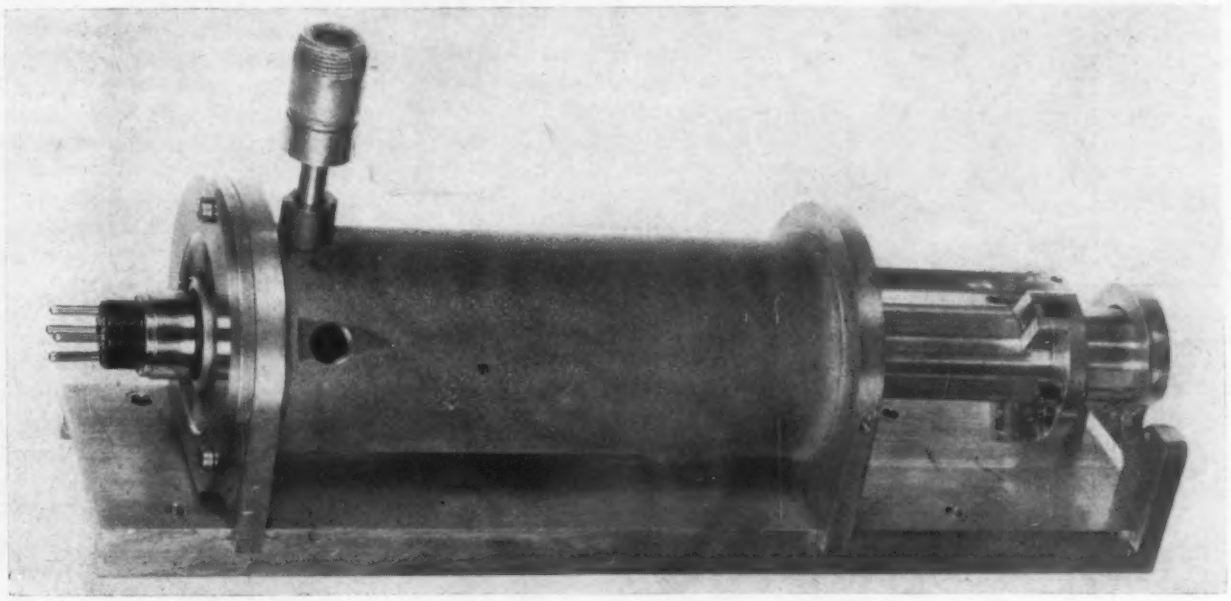
flector voltage of approximately −130 volts. For this reflector voltage, the 1¾ mode is approximately at 15.8 cm, the 3¾ mode at 7.5 cm, the 4¾ mode at 5.7 cm. . . . If any one of these had corresponded to the wavelengths for the cavity modes, there would be the possibility of the system sustaining oscillation in either frequency, and thus mode-jumping could occur. Because operation must be continuous over the band, care had to be taken that at no point would mode interference be experienced; this is accomplished in part through achieving the proper cavity match and in part through shifting the tube characteristics by adjustment of the internal parameters.

To cover the frequency range, the position of the reflector was varied. The required range was approximately 2.0 to 4.3 kilomegacycles (kmc) and the problem of obtaining it was complicated by the requirement of operating only in the 2¾ mode. The spacing was adjusted to give 2.0 kmc with the reflector at about −35 volts; this value was determined primarily by considerations of reflector current tolerable in the application. The first prototypes of the 6BL6 failed to reach the higher frequency, although in a radial cavity they had operated satisfactorily. The exact reason for this discrepancy is not fully evident. However, by adjusting the internal tube parameters and the position, size, and orientation of the coupling loop, the desired range of operation in the special cavity was obtained.

Another interesting instance in which cavity and tube parameters are almost inseparable, in considering characteristics and operating limits, is in electronic tuning. A variation of reflector voltage will produce not only a change in power output, but also a variation in frequency even though the cavity setting is fixed. Figure 7 shows typical electronic tuning curves taken for optimum loading (that it, with the coupling adjusted to give maximum power output at the center points of the curves).

### Cavities for the Tube

In the discussion so far, reference has been made particularly to a coaxial cavity with which much of the work was done. This cavity was chosen primarily because of an immediate application (a widerange superheterodyne receiver) requiring special mechanical and electrical design features. Here a noncontacting plunger, which is ball bearing



**Noncontacting plunger and roller bearings of this coaxial cavity of Airborne Instruments Laboratory make it capable of thousands of complete tuning cycles without appreciable wear**

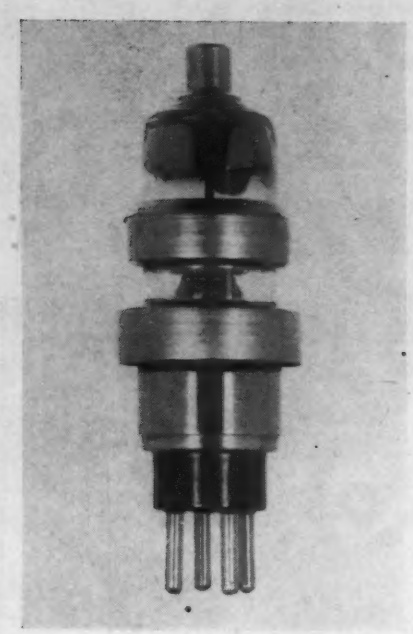


FIG. 2—Actual size picture of 6BL6 klystron for wider range tuning

nated as the time in cycles during which an electron of average velocity drifts from the grids toward the reflector and back) of the earlier tubes was different from that required for this application. (2) a match between tube and cavity is desirable (that is, the tuning curve of wavelength as a function of cavity plunger displacement should represent the tuning curve of an ideal resonator as nearly as possible). Inasmuch as the electrical part of the cavity design was standardized and was based on a tube somewhat different from the earlier ones, the problem was resolved into one of changing the tube to match the established cavity. (3) It is important to insure, not only against mode interference from a higher order $TE_{1,1}$ mode at the high-frequency end of the band, but also against combinations of cavity modes and reflector modes which are such that serious interference and frequency jumping are possible.

The first of these problems to be solved was that of obtaining a proper match between tube and cavity. The curve of an ideal resonator (that is, one in which resonant wavelength plotted as a function of plunger displacement is a straight line with a given slope) had to be closely duplicated. The problem was to change the capacitance between the two resonator grids and electronic admittance of the tube in such a fashion that the tuning curve of the cavity-tube combination would be essentially a straight line, having the same slope as the curve for the ideal resonator alone. These curves, obtained by Airborne Instruments Laboratory, are compared in Fig. 5; the curve for the ideal resonator has arbitrarily been shifted to the left. The important feature is that these curves are nearly parallel, indicating the same slope.

Matching the tube to the cavity also reduced interference between modes. Part of the mode interference was due to a $TE_{1,1}$ mode tuning curve intersecting the desired TEM mode near the short wavelength end of the band. Improper cavity match caused this mode to move from its calculated position outside the desired band to a point where serious difficulty resulted. Achieving proper cavity match eliminated this trouble.

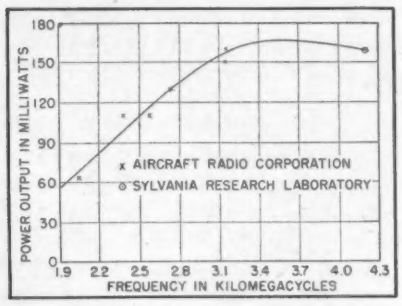



FIG. 3—Power output from typical tube

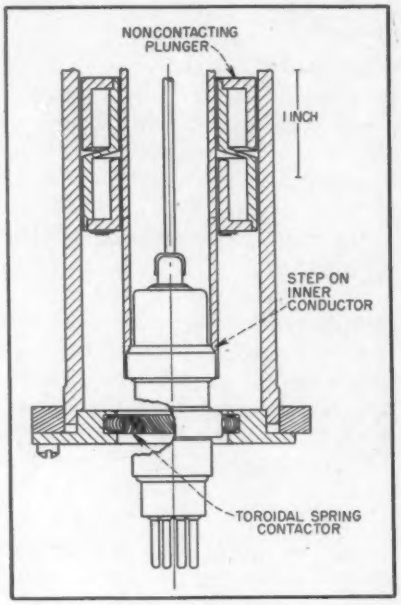



FIG. 4—Special features of cavity

Discussion of cavity matching introduces another interesting item: that of the interdependence of the electrical features of the cavity and the external physical dimensions of the tube. The diameter of the upper disk determines, to a large extent, the minimum diameter of the inner conductor of a coaxial cavity. This disk diameter was so chosen that a commercial size tubing could be used in cavity manufacture, and at the same time this size was convenient to tube design and manufacture. Because the ratio of diameters of inner and outer conductors of the cavity is fixed by electrical cavity design consideration, the diameter of the outer conductor is fixed by this choice. The diameter of the lower disk cylinder of the tube must then be larger than the upper disk cylinder and smaller than the diameter of the outer cavity conductor. One inch was chosen for the lower disk of this tube; it fits the above condition and at the same time is of ideal size for the toroidal spring contactor described above.

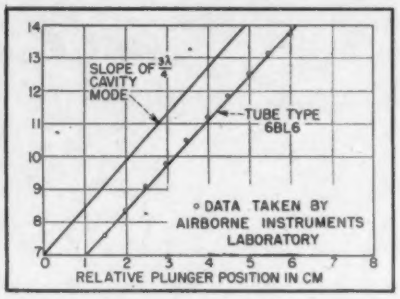

SLOPE OF 3λ/4 CAVITY MODE
TUBE TYPE 6BL6
o DATA TAKEN BY AIRBORNE INSTRUMENTS LABORATORY
RELATIVE PLUNGER POSITION IN CM

FIG. 5—Tuning curve of klystron-cavity combination

### Frequency Moding

The second major problem to be solved was that of frequency-moding or frequency-jumping. This problem is one of eliminating combinations of cavity modes (that is, the $\lambda/4$, $3\lambda/4$ and $5\lambda/4$ . . . modes of the cavity) for a given plunger position, which would combine with reflector modes, shown in Fig. 6, of the tube to give interference and frequency-jumping. Size consideration makes it desirable to operate on the $3\lambda/4$ mode of the cavity; thus, if the plunger is set for operation at 10 cm, the cavity is also resonant at 30 cm, 6 cm, 4.3 cm, 3.3 cm. To operate in the $2\frac{1}{2}$ reflector mode at 10 cm, the tube has a re-

# VOLTAGE-REGULATED POWER SUPPLIES

**A nonmathematical solution is traced from simplified theory. Actual values of circuit elements necessary to build a power pack and three-tube control are computed. Practical suggestions are given for physical layout and elimination of ripple**


**By PAUL KOONTZ** and **EARLE DILATUSH**

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SIMPLY stated, the action of a voltage regulated power supply is to cancel any attempted fluctuation of its output voltage whether caused by input (line) change, or output (load) change. One way to become familiar with the regulating action of this circuit upon input variations is to trace the path of the supply ripple. In the usual power supply, this disturbance consists mainly of 120-cycle sine-wave a-c, with amplitude from a fraction of a volt to several volts. In Fig. 1, this voltage appears across points $A$ and $B$, and produces a flow of current through $V_1$ (whose initial action is that of a diode) and $R_1$. A portion of the voltage drop across $R_1$ caused by this current is applied as bias to the control grid of the amplifier tube $V_2$. Since $V_3$ holds the cathode of $V_2$ at a fixed point above ground, $V_2$ amplifies this variation, causing it to appear in inverted form across the load resistor $R_2$. Since $R_2$ also serves as the bias resistor for $V_1$, it produces through $V_1$ an inverted version of the original ripple current. Because this and the original ripple are approximately equal but opposite in phase, cancellation occurs, giving as the end result an almost ripple-free output across $C$ and $B$. A similar cancellation is produced by any attempted fluctuation of input voltage to the regulator.

Attempted output voltage changes caused by load variations are similarly cancelled because they, too, are applied to the grid of the amplifier tube $V_2$.

### Expansion of Simplified Theory

It was assumed above that the grid of $V_2$ is the sole means of control. That is, that the change voltage applied to it by $R_1$ is the only acting control voltage, and that the grid of $V_2$ is the only point to which control voltage is applied. A complete analysis presents quite a different picture. Not only are other control voltages present, but they are introduced at several different points in the circuit.

Variations of the unregulated supply voltage can act as a control source when applied to any of the amplifier tube elements. When the screen of $V_2$ is fed by a bleeder from the unregulated supply as in Fig. 2, the variations of that supply voltage appear across the screen-to-cathode impedance of $V_2$ and are amplified by the screen which acts like a low-gain control grid. This control-effect produces across $R_3$ a voltage of the proper phase to effect cancellation of the input changes, but of an amplitude that is normally much greater than that needed for cancellation.

Similarly when $V_3$ is fed by a bleeder from the unregulated sup-

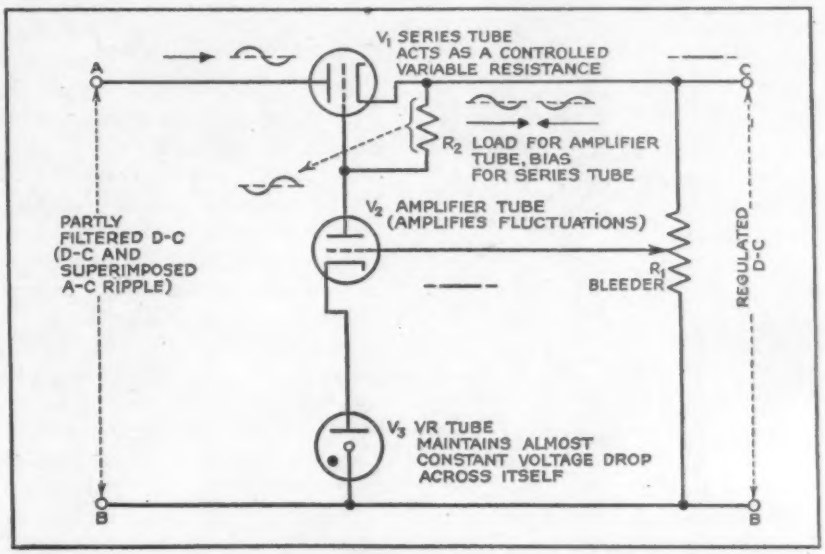



**FIG. 1—Fundamental elements of a voltage-control designed to follow a conventional rectifier**

mounted making possible an exceedingly large number of tuning cycles without wear of cavity parts, is used; contacting and tube positioning design features discussed above were incorporated. A second cavity in which a considerable amount of testing was done, including most of the power output measurements, is similar in many respects to the one previously discussed except that it has a contacting-type of plunger.

A third cavity used with the tube is a radial type having seven tuning lugs, instead of one plunger, to adjust the frequency. By adjusting these lugs in or out, the cavity is tunable over a wavelength range of 6.5 to 8.1 cm rather than the full octave coverage of the other two cavities.

The low-frequency limits, other than those imposed by inherent design features of the cavities, arise primarily from limitations of voltages which can safely be applied to the tube for each reflector mode. Typical mode characteristics are shown in Fig. 6. It will be observed that the curve for each mode is terminated at a reflector voltage of −25 to −35 volts; reflector current becomes noticeable at less negative voltages. The magnitude of the reflector current which can be tolerated depends, to a great extent, upon the power supply. This tolerance established a lower practicable limit arbitrarily set at 1.25 kmc for the 1¾ mode and 1.8 kmc for the 2¾ mode. The high-frequency limit has been established so far by cavity limitations. Other factors which might affect this limit are the maximum practical limits of voltages which can be applied to the reflector and conditions such as loading, which require a lower value of electronic admittance within the tube than is obtainable.

The choice of the 2¾ mode resulted from a compromise between power output and stability of operation. In general, the higher order modes operate more stably, whereas the lower modes usually give higher power output. Choice of the 2¾ mode gives a stable mode with good power output.

Figure 6 shows the mode characteristics with a tube operating in the Airborne Instruments Laboratory cavity. Open areas represent regions in which the tube oscillates with sufficient strength to give an indication on a crystal output meter. The locus of maximum power for each mode is a line near the center of the area. The power output distribution along any ordinate across these modes follows the curves of Fig. 7.

These mode characteristics serve a very practical purpose other than to present the ranges and modes available from the tube. In a wide-range local oscillator, the frequency is changed continuously by moving the cavity plunger. These curves show the manner by which reflector voltage must be varied when the frequency is changed. As may be deduced from Fig. 6, it usually is sufficient to track the reflector voltage near the center of the characteristic. Combining this characteristic with the tuning curve, Fig. 5, it is possible to design the tracking mechanism.

Figure 3 shows power output as a function of frequency for the 2¾ mode. At each frequency, the power determination was made after the output had been maximized by adjusting the reflector voltage and the coupling loop. Power output is well above 100 milliwatts over most of the band. In a similar fashion, the power output of the 1¾ mode falls off rapidly only for frequencies below 1.3 kmc.

In conclusion, the authors wish to acknowledge, with sincere appreciation, the work done at the Radio Research Laboratory at Harvard University, that of Airborne Instruments Laboratory, and of Aircraft Radio Corporation with reference particularly to the solutions to the cavity problems, and the work of Dr. V. B. Corey while a member of the Research Laboratory, Sylvania Electric Products, Inc., relative to this project.

**TABLE I—Ratings and Characteristics**

| | |
|---|---|
| **RATINGS** | |
| Heater voltage ± 8 per cent (a-c or d-c) | 6.3 volts |
| Heater current | 0.65 ampere |
| Max negative reflector voltage | 400 volts |
| Min negative reflector voltage | 0 volts |
| Max positive grid No. 1 voltage | 0 volts |
| Max grid no. 2 voltage | 350 volts |
| Max grid no. 3 voltage | 350 volts |
| Max operating freq | |
| 1¾ mode | 3.3 kmc |
| 2¾ mode | 4.8 kmc |
| 3¾ mode | 6.0 kmc |
| Min operating freq | |
| 1¾ mode | 1.25 kmc |
| 2¾ mode | 1.75 kmc |
| 3¾ mode | 2.2 kmc |
| Max heater-cathode voltage | 45 volts |
| **TYPICAL OPERATION** | |
| Heater voltage (a-c or d-c) | 6.3 volts |
| Heater current | 0.65 ampere |
| Grid no. 1 voltage | 0 volts |
| Grid no. 2 voltage | 325 volts |
| Grid no. 3 voltage | 325 volts |
| Cathode current (approx) | 25 ma |
| Reflector voltage | adjusted for max power output |
| Reflector voltage at $f$ = 2.14 kmc (2¾ mode) | −40 volts |

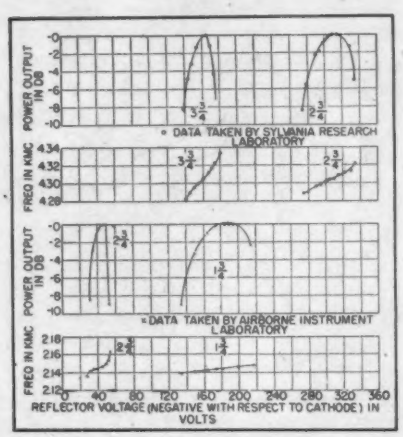
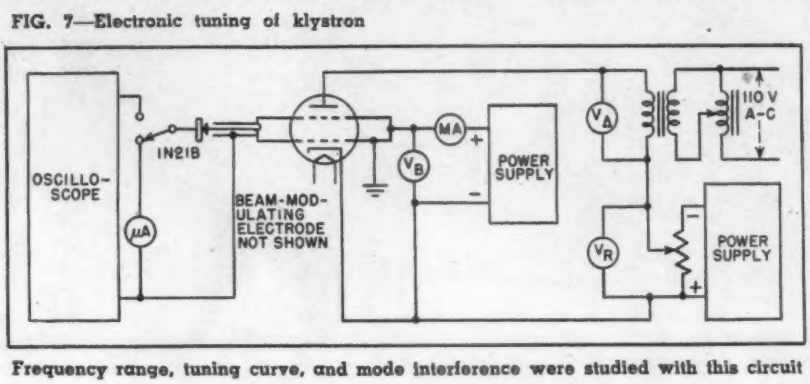

POWER OUTPUT IN DB
DATA TAKEN BY SYLVANIA RESEARCH LABORATORY
FREQ IN KMC
DATA TAKEN BY AIRBORNE INSTRUMENT LABORATORY
REFLECTOR VOLTAGE (NEGATIVE WITH RESPECT TO CATHODE) IN VOLTS

FIG. 7—Electronic tuning of klystron




Frequency range, tuning curve, and mode interference were studied with this circuit

the rectifier tube, $V_4$; the filter choke, $L_1$; and the power transformer, $T_1$.

Tubes commonly chosen for series service include 2A3, 6A3, 6B4, 6L6, 6V6, 6Y6, and 807. For our supply the recently introduced 6AS7G, a twin triode expressly designed for this service is chosen. Their extremely low plate resistance allows the use of a lower voltage drop across them, hence a reduced high-voltage winding on the power transformer. The heater-cathode rating of ±300 v makes possible the paralleling of their filaments with that of the amplifier tube. Only two of these tubes are needed because of their current-carrying ability, with a resultant saving of space.

A suitable filter choke will have low internal resistance and adequate current carrying capacity. Inductance rating is of secondary importance. A 5 to 10 henry choke with 50 to 200 ohms internal resistance, and rated to carry at least 225 ma will be satisfactory. The one selected for this example is rated at 5 henries at 225 ma with 100 ohms d-c resistance.

The rectifier selection is easy, for the 5U4G, 5Z3, 5T4, and the 5X4G can all handle the current and voltage requirements. The 5U4G is chosen because of its general availability.

#### Selecting a Power Transformer

In the selection of a power transformer, we must first determine the voltage needed out of the rectifier. This will consist of the sum of the voltage drops across the filter choke, series tubes, and output load. The use of the following procedure is necessary to determine that voltage:

1—Inspect the characteristic curves of the selected series tube. determine from them the lowest allowable plate voltage for the maximum current specified.

*Example:* Each side of a 6AS7G will deliver 56 ma at 20 v, so 2 6AS7G's in parallel will provide the required 225 ma total current, including approximately 25 ma current consumed internally by the power supply.

2—Increase the minimum working plate voltage by a sufficient margin to allow for possible component variations. This also is necessary to allow proper control of the series tube, since its bias must swing symmetrically about a center point and never drop to zero.

*Example:* 20 v plus 20 v margin equals 40 v minimum operating plate voltage.

3—Next determine the minimum voltage allowable at the plates of the series tubes. This is the highest power-pack d-c output voltage plus the voltage determined in step 2. Note that this must be delivered to the plates of the series tubes under the condition of lowest allowable line voltage and highest rated output current of the pack.

*Example:* 300 v pack output plus 40 v from step 2 = 340 v delivered at 225 ma total drain, and 105 v line input.

4—Add the voltage obtained in step 3 to the IR drop across the filter choke (at full 225 ma current) to find the voltage the rectifier must deliver at lowest line input.

*Example:* $E = IR = 0.225 \times 100 =$ 22.5 v choke drop. 340 v + 22.5 v = 362.5 v at 225 ma which the rectifier must supply at 105 v line input.

5—Refer to the characteristic curves of the rectifier selected. From them find the input voltage to the rectifier that will produce the output voltage determined in step 4. Be sure to take into consideration the type filter (choke or capacitor input) and the size of its components.

*Example:* 5U4G, capacitor input filter using 8μf input capacitor. 350 v a-c rms in, equals the required 362.5 v out at 225 ma.

6—Calculate the highest a-c input voltage to the rectifier that will result when the line input voltage is increased to its upper limit.

*Example:* Voltage ratio of the power transformer equals 362.5/105 or 3.33. 125 v × 3.33 = 416 v a-c out.

7—Again refer to the rectifier tube curves. Determine the d-c voltage out of the rectifier for the a-c voltage into it calculated in step 6.

*Example:* 416 v in = 435 v d-c out (at 225 ma drain).

8—See what the maximum wattage dissipation in the series tube will be, under the worst operating conditions; that is at maximum current drain, maximum line input voltage and lowest d-c output voltage.

*Example:* 435 v − 22.5 v choke drop = 412.5 v applied to the series tubes. This, minus 250 v (the lowest output voltage) = 162.5 v across the series tubes. Therefore, since $W = EI$, 162.5 v × 0.225 amp = 37 w total dissipation.

9—Using the maximum a-c input voltage to the rectifier (determined in step 6), and the minimum current drain (set by the limits), inspect the rectifier tube characteristics and find the d-c output voltage for these conditions.

*Example:* 5U4G, 416 v a-c, 100 ma total drain; the d-c out of the rectifier is 500 v.
This voltage, minus the lowest pack d-c output voltage set by the limits, is the maximum voltage that will appear across the series tubes.

*Example:* 500 v −10 −250 v equals 240 v maximum across the paralleled 6AS7Gs.

10—If the ratings of the series tubes (maximum wattage and plate voltage) are not exceeded under the conditions imposed by the

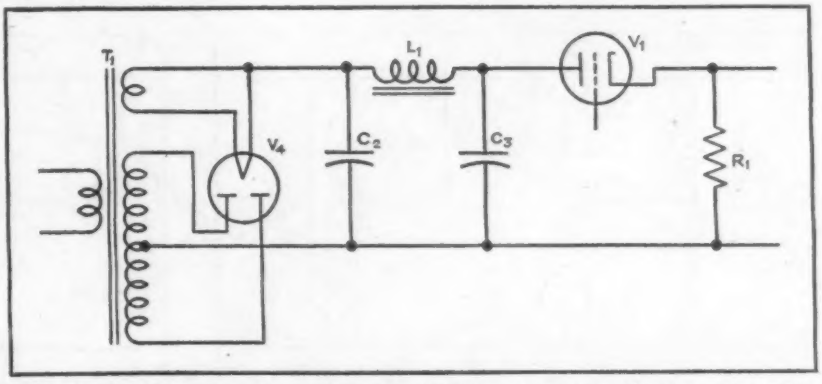



**FIG. 3—Supply section of a voltage-regulated power unit with the series tube inserted to illustrate its action**

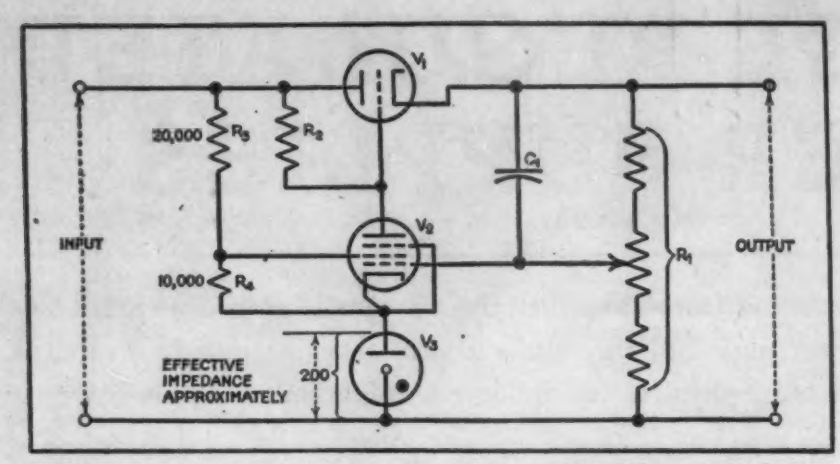



**FIG. 2—A voltage-control circuit in which several elements of the control tube are fed from the unregulated input**

ply, a portion of the variation in that supply appears across $V_3$, which forms the cathode circuit of $V_2$. Hence $V_2$ has impressed on its cathode (in series with its grid return) a portion of the input change. The amplitude of these changes depends on the effective impedance of $V_3$, which is usually from about 200 to 1,000 ohms. The effect of these changes opposes that caused by the grid and screen controls.

The impedance of $V_3$ also causes the introduction of another voltage into the grid return of $V_2$. This additional control voltage, resulting from variations of the plate and screen current of $V_2$, acts degeneratively to reduce the gain of $V_2$.

### Evaluation of Control Factors

The effectiveness of the control action of the grid may be expressed in its simplest form as

$$\text{Resultant fluctuation of the supply output} = \frac{\text{Attempted excursion}}{\text{Gain of the amplifier stage}} \quad (1)$$

The effect of the screen control, in the absence of grid control, may be stated as

$$\text{Resultant fluctuation of the supply output} = \text{Difference between (a) [attempted fluctuation] and (b) [portion applied to screen times screen gain]} \quad (2)$$

The composite output fluctuation, resulting from both grid and screen control may be found by considering the result obtained from Eq. 2 as the attempted excursion in Eq. 1.

$$\text{Resultant fluctuation of the supply output} = \frac{\text{(Original excursion) minus (portion applied to screen times screen gain)}}{\text{Gain of amplifier stage}} \quad (3)$$

For the moment, let us assume that the resultant fluctuation in Eq. 3 equals zero. In this event, the final fluctuation on the output is equal to that value which produces at the grid of $V_2$ an exact duplicate of the voltage present on the cathode.

$$\text{Resultant fluctuation of the supply output} = \text{Voltage on output which produces at the grid of } V_2 \text{ a change voltage duplicating that on the cathode.} \quad (4)$$

### Choice of Ratings

In the average power supply, the grid, in spite of the other controls, is able to reduce any ripple presented to it to a value comparable to that existing on the cathode. This is true even though the screen overcompensates in the usual case. The value existing on the cathode will vary widely when different $V_2$'s of the same type are substituted in the same chassis. Conventional design for a supply furnishing an output of 250 to 300 volts d-c produces a ripple content of approximately 0.04 v rms. The d-c regulation is usually maintained within about ±2 volts.

Before designing any regulated supply, it is of prime importance to list the actual demands to be made on it. Instantaneous peak current demand (as distinguished from maximum average current demand) is probably first in importance. These supplies are not reservoirs, hence lose both control and effectiveness when subjected to any instantaneous load even slightly beyond their rated capacity. The frequency of demand is unimportant, however, if it lies below approximately 20,000 cycles per second. Above this frequency the effective impedance of the supply increases rapidly because of the inability of tube $V_3$ in the amplifier cathode circuit to regulate. A rise in supply impedance can be counteracted by shunting a paper capacitor of 1 or 2 microfarads across the regulated output. When this capacitor is included, the supply can be used to feed equipment calling for microsecond pulses of high amplitude.

Selection of the output voltage to be provided is also important. To reduce the cost of components, an output range of 250 to 300 v is favored, when that is adequate for the equipment being fed. Higher output voltages are easily produced, but require more expensive components. A wide range of output voltage adjustment should also be avoided unless there is a specific need for it. The usual dependability of domestic supply lines makes it unnecessary to provide against large line voltage changes.

### Design of Supply Section

For design purposes, supply and control circuits can be considered separately. The supply portion, as considered here, consists of the components shown in Fig. 3. This circuit differs from an ordinary unregulated power supply only in the addition of $V_1$, which may for the moment be considered as a variable series resistance introduced for control purposes.

To illustrate design procedure a set of requirement limits has been chosen based on commercial ratings for supply components.

The limits decided on are: output voltage, 250-300 v; output current range 75-200 ma; power line fluctuations of ±10 percent.

On the basis of these limits we may now choose the series tube, $V_1$;

bleeder value will be approximately 0.25 megohm.

The necessary resistance values for $R_5$, $R_6$, and $R_7$ will vary with the regulated output voltage of the pack, and while they could be computed, a simpler method for determination is available. Substitute a 0.25 megohm potentiometer for $R_1$. With the pack operating, adjust the potentiometer to obtain a pack output voltage approximately 10 percent higher than the highest desired output voltage. Disconnect the potentiometer, and record the resistance from arm to positive end. Reconnect the potentiometer and set the pack in operation. Readjust it to give an output voltage 10 percent lower than the lowest desired output voltage. Again disconnect, and record the resistance from the arm to minus end. You now know the values of $R_5$, $R_6$, and $R_7$ that will produce the desired range. To make the resultant values of $R_5$, $R_6$, and $R_7$ fall on commercial resistance values, the total bleeder resistance $R_1$ may be adjusted upwards or downwards by a factor of plus or minus 25 percent.

*Example:* $R_5$, 120,000 ohms; $R_6$, 50,000 ohms; and $R_7$, 82,000 ohms for an approximate output range of 220 to 330 v for this particular supply.

The grid coupling capacitor, $C_1$, which presents a low impedance path to the grid for attempted high and medium frequency changes in the output, is usually about 0.25μf. Larger values, while transferring more of the low (ripple) frequency variations to the grid, may cause undesirable effects due to time lag in their transmission.

### Design for Minimum Ripple

A ripple voltage of 0.02 to 0.05 v rms in the output of a standard voltage-regulated power supply is usually satisfactorily low. If troublesome, it may often be reduced by carefully selecting tube $V_3$ that is used as voltage reference, particularly when the screen and $V_3$ bleeder are connected to the unregulated supply voltage.

If unusually low ripple must be obtained, the circuit modification shown in Fig. 5 can be used. Analysis of the operation of this circuit will show that the degree of ripple reduction is not limited by the amplifier gain but may be made practically infinite. This effect is accomplished by feeding the screen of the amplifier tube $V_2$ a controlled amount of the input ripple. The screen, acting as a low-gain control grid, produces across the series tube a voltage equal to the original ripple but of opposite phase. Control of the amount of ripple fed to the screen grid is performed by the 0.5 megohm potentiometer.

The most satisfactory degree of ripple cancellation can be assured by placing the pack in operation with its actual load and an oscilloscope connected across the output. After all other adjustments have been made, the ripple can be cancelled by adjusting the potentiometer.

The degree of ripple cancellation does not depend on the amount of ripple present, and almost complete cancellation can usually be effected with ripple inputs of 50 v or less. One of the supply modifications this suggests is the reduction of the filter components to a single capacitor following the rectifier. Powerpack output ripple of 0.002 v or less can be obtained under these conditions. When a normal filter is used, the residual ripple may be too small to be observed on a sensitive oscilloscope.

### Optimum Regulation

Variations in output voltage owing to changing load will be minimized by the use of a low impedance supply to the series tube. The use of a mercury-vapor type rectifier will often give the greatest improvement in that respect.

Any means of increasing the effective gain of the amplifier stage will also improve the regulation. Three schemes advanced for this purpose include: substitution of a constant voltage device (such as neon lamps, VR tubes, or batteries) for the portion of the amplifier grid bleeder between the grid and regulated B+; substitution of a constant current device (such as a pentode tube or inductance) for the portion of the amplifier grid bleeder between grid and B−; the use of a multiple stage amplifier.

Another method of improving regulation is to connect the screen of the amplifier tube to a bleeder from unregulated B+.

### Physical Arrangement

Layout of the supply portion follows the established rules for power supplies. To avoid hum pickup by the control section it is desirable to place the entire supply section at one end of the chassis. Thus, no a-c wiring but that for the filaments need be close to the sensitive control circuits.

The series tube placement requires consideration of the problem of heat elimination. Nearly a fourth of the total power consumed by the entire supply is dissipated by the series tubes under some conditions of operation.

The control portion is more demanding in its placement and wiring needs. To realize full benefits from a supply of this type, hum pickup on the amplifier tube wiring must be eliminated. All wires to the grid of the amplifier should be short, and capacitance between them and other wires or chassis reduced to a minimum. The capacitor between the amplifier grid and regulated B+ should be mounted away from the chassis to avoid unwanted capacitance to ground. The voltage adjusting potentiometer should preferably be located on the chassis adjacent to the amplifier tube socket. If panel control is required a shaft extension is preferable to locating it on the panel. Hum pickup from 60 cycles on long leads to this control is often difficult to eliminate. A safe rule to follow is to consider the amplifier tube as an r-f amplifier, and to use appropriate wiring precautions.

An oscilloscope is the only satisfactory means of observing the minute fluctuations present on the output of a voltage-regulated power supply. It is also extremely useful for trouble shooting as well as for measuring the variations present.

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limits, we may now easily determine the nominal voltage of the a-c high voltage winding on the power transformer, by multiplying its voltage ratio by the nominal line voltage.

*Example:* 3.33 × 115 = 383—so a rating of 380 v would be satisfactory.

Additional design considerations for the supply section stipulate rectifier tubes having good regulation (low internal voltage drop). If a capacitor input filter is used, the input capacitance should be at least 8μf. When a choke input filter is used a swinging choke is advisable following the rectifier tube.

### Series Tube Circuit Design

Standard practice dictates the use of supressors in control grid and plate circuits (screens, too, if used) when series tubes are paralleled for greater current capacity. Their elimination would result in highly unstable or erratic operation. It is preferable that these supressors be mounted with one end directly supported by the tube socket lug to which it connects. Resistance values of 50 ohms for the plate, and 100 ohms for the grid and screen are satisfactory.

### Design of Control Section

The control circuit shown in Fig. 4 is typical. A sharp-cutoff pentode is more suitable than a remote-cutoff pentode for use as the amplifier $V_2$. Its lower plate current allows the use of a high value of plate load resistance $R_2$, resulting in higher gain and less degeneration. The highest gain of the amplifier will be obtained when $R_2$ approaches the plate resistance of the amplifier tube. This suggests a value for $R_2$ of from 0.5 to 1 megohm.

The voltage reference source is usually a cold-cathode tube of the VR type, although batteries or a neon bulb could be used. Tubes are preferred because of their long life and low effective impedance. High impedances at $V_3$ will cause an increased ripple output, as well as poorer regulation because of increased degeneration in the amplifier stage. Impedances presented by tubes of the VR type approximate 200 to 1,000 ohms.

Selection of the specific tube for any given application depends on fulfilling the following requirements:

1—The amplifier tube $V_2$ must be provided with adequate plate voltage over the entire range of operation.

*Example:* (based on the limits used for computation in the supply section: 250 to 300 v at 75 to 200 ma external drain over 105 to 125 v line input.)

The amplifier plate voltage will be lowest with highest line and lowest output voltage and current—125 v line, 75 ma external drain at 250 v output. Reference to step 9 in the supply section shows 240 v across the 6AS7G's under this condition. Inspection of the characteristic curves for the 6AS7G shows that 130 v bias will be required to limit the current through each section to 25 ma (¼ of the 100 ma total). The voltage between the amplifier plate and ground is the output voltage of the supply 250 v, minus the bias voltage for $V_1$ 130 v; or 120 v. A small voltage must be maintained between plate and cathode of the amplifier tube $V_2$.

2—The grid of the amplifier tube $V_2$ should receive as large a percentage as possible of the total fluctuation present on the output. Hence the highest voltage VR tube allowable by step 1 should be used.

*Example:* A type OC3/VR105 is indicated here.

The bleeder consisting of $R_3$ and $R_4$ must supply $V_2$ at least 8 ma of current, and must maintain the screen of $V_2$ at a suitable voltage above its cathode.

*Example:* Lowest unregulated d-c is approximately 340 v (at 105 v line input and 225 ma total drain), therefore the total resistance $R_3$ plus $R_4$ will be: (340-105) /0.008 = 235/0.008 = 30,000 ohms.

The section between the screen of $V_2$ and its cathode (plate of $V_3$) must have a drop of approximately 60 v for adequate screen supply. Thus $R_4$ will be: 60/0.008 = 7,500 ohms. This gives suitable values of $R_3$ and $R_4$ as 22,500 ohms and 7,500 ohms respectively. Wattage ratings of $R_3$ and $R_4$ must allow for the condition of highest unregulated supply voltage (500 v as determined in step 9 of supply). Therefore 500—105/30,000 = approximately 13 ma. Wattage dissipated in $R_3$ = 0.013 × 0.013 × 22,500 ≐ 3.8 watts. Therefore $R_3$ requires a 5 watt resistor. Similarly, $R_4$ calls for a 2 watt rating. Screen current has been neglected as negligible in these computations.

The amplifier grid bleeder consisting of $R_5$, $R_6$, and $R_7$ can be determined as follows: Its total resistance $R_1$ should be sufficient to allow the conservative use of small fixed carbon resistors at $R_5$ and $R_7$, and a standard potentiometer at $R_6$. However, if excessively high values are used, $V_2$ exhibits troublesome hum pickup from its grid wiring.

*Example:* If 300 v is the maximum pack output, a total suitable

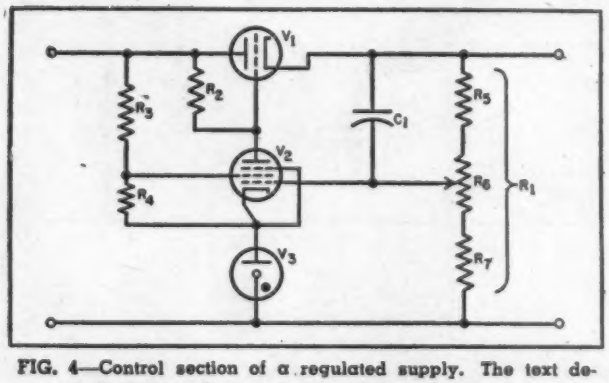


FIG. 4—Control section of a regulated supply. The text describes the values and reasons for selecting them

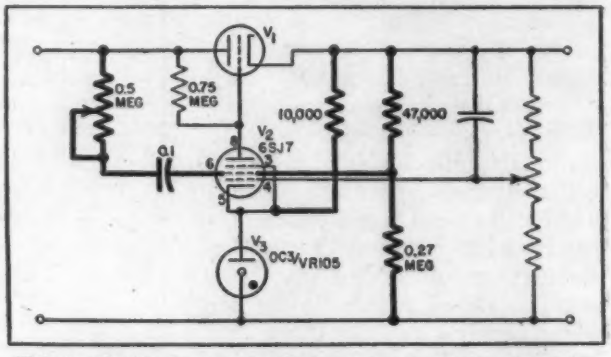


FIG. 5—Modification of the fundamental regulating circuit for extremely low ripple is shown by the heavy circuit lines

# IMPEDANCE

**A slotted line, used in conjunction with a variable-reactance line that balances out reactive impedances, is readily adapted to measurements of impedance, antenna phasing, and directivity comparisons. Equipment for unbalanced and balanced loads are described**

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RADIO-FREQUENCY MEASUREMENT in the two lower television and frequency-modulation bands cannot be conveniently made using the equipment and techniques of either the lower-frequency bands or the microwave region. However, in this region from 44 to 216 megacycles the slotted transmission line is a simple device for measuring impedances, especially if it is used somewhat differently than it is normally used in the microwave region.

### Accuracy of Standing Wave Measurements

A slotted line is most accurate when used in measuring impedances that are of the same order of magnitude as the characteristic impedance of the line itself. For impedances greatly different from that of the line, the attenuation of the transmission line, if any, connecting the slotted line to the impedance being measured comes into the picture. This necessitates cumbersome corrections. Fortunately, at these frequencies coaxial cable is available that has sufficiently low attenuation so that several feet of it can be connected between the slotted line and the unknown impedance without necessitating correction for impedances that cause standing-wave ratios (swr) up to 15 to one, and still give reasonable accuracy.

Attenuation in the slotted line itself also causes errors in measurement. These errors normally appear as errors in the measured swr and in the position of a voltage or current minimum as measured with respect to some reference point, such as the point at which the unknown impedance is connected. A small percentage error in determining the position of the minimum can cause an extremely high percentage error in the measured impedance for impedances causing high swr on the measuring line.

As an example, if an impedance of 100 + j300 ohms is to be measured on a 50-ohm slotted line, a 2-percent error in swr can give a 10-percent error in resistance and a 3-percent error in reactance. An error of 2 percent of a half wavelength in determining the position of a voltage or current minimum, however, can cause a 150-percent error in resistance and a 43-percent error in reactance.

### Impedance Measuring Equipment

Figure 1 shows an equipment arrangement for measuring impedance by means of two swr measurements and no position measurement. A sleeve is placed around the coaxial cable connecting the unknown impedance to the slotted line. The distance from the load end of this sleeve to the point where it is shorted to the outside of the coaxial cable is movable by means of a sliding plunger. This sleeve forms the outside conductor of a second coaxial line, which has as its inner conductor the outside conductor of the coaxial line leading from the load to the slotted line. This second larger coaxial line is shorted by the plunger at one end and has its other end connected in series with the outer conductor of the coaxial line leading to the slotted line and the unknown impedance. By varying the position of the sliding plunger the reactance introduced by the shorted line can be varied through all values both positive and negative, limited only by the Q of the line.

By sliding the plunger until the minimum swr is obtained, the reactance of the unknown impedance

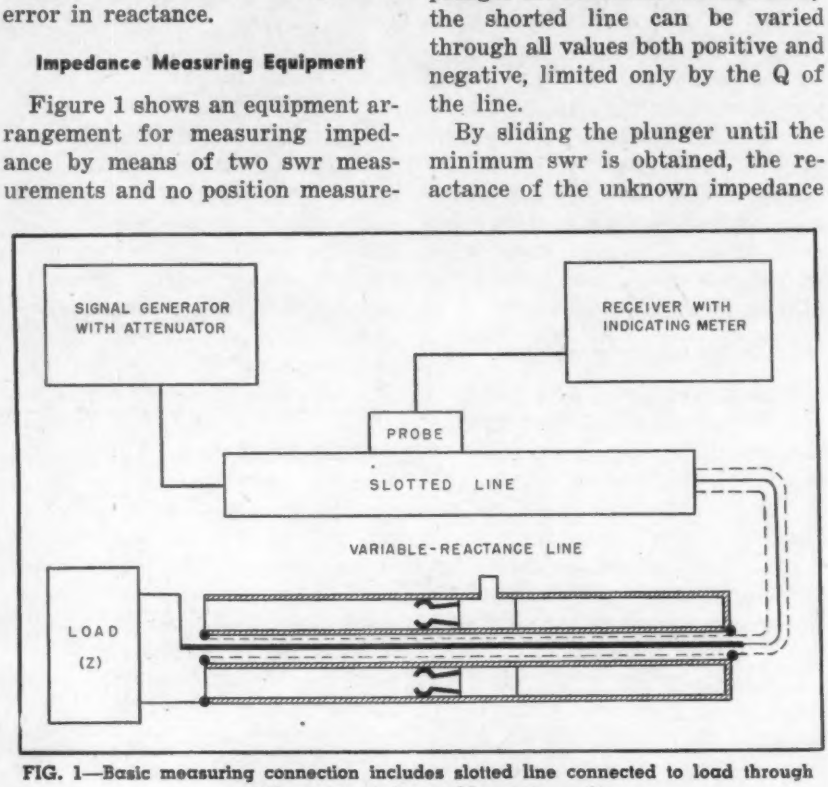



**FIG. 1—Basic measuring connection includes slotted line connected to load through specially-constructed variable-reactance line**

# MEASUREMENTS AT VHF

will be tuned out. The swr with this tuning then indicates the resistive component of the unknown impedance by itself. The value of this resistance is the characteristic impedance of the slotted line either multiplied or divided by the swr, depending upon whether the resistive component of the unknown impedance is larger or smaller than the characteristic impedance of the slotted line.

### Checking Conditions

To check which of these two conditions exists, it is only necessary to short-circuit the inner coaxial cable at the load and note the position of the minimum on the slotted line. If the position is the same as it was before the short was made but after the plunger had been adjusted for minimum standing wave ratio, the resistance of the load is on the same side of the characteristic impedance of the slotted line that a short circuit is, namely lower, so that a division must be performed to get the value of the resistance. If the minimum with the short-circuit in place is 90 degrees away, the resistance is higher than the characteristic impedance of the line and a multiplication must be performed to obtain the value of the resistance.

### Reduction of Data

In order to get the reactance, it is necessary to refer to one of the various transmission line charts, such as the Smith chart, which are plotted in a variety of handbooks and periodicals. Although these charts appear in several different forms and look quite different they are just different conformal transformations of the same relationships between voltages and currents at different points of a transmission line, and contain the same information.

Figure 2 shows a form of transmission line chart in which the horizontal axis represents resistance and the vertical axis represents reactance. The two circles shown represent points of constant swr which degenerate into a point at $Z_0$ when the swr ratio is unity.

In the measurement just described, the smaller circle corresponds to the swr measured with the reactance of the unknown

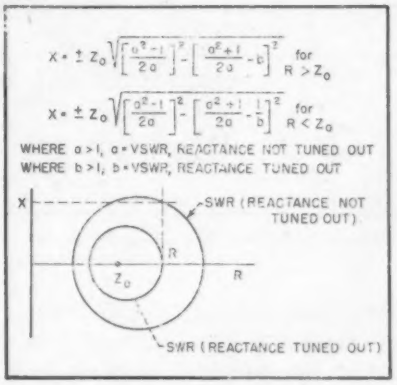

$X = \pm Z_0\sqrt{\left[\frac{a^2-1}{2a}\right]^2-\left[\frac{a^2+1}{2a}-b\right]^2}$ for $R > Z_0$
$X = \pm Z_0\sqrt{\left[\frac{a^2-1}{2a}\right]^2-\left[\frac{a^2+1}{2a}-\frac{1}{b}\right]^2}$ for $R < Z_0$
WHERE a > 1, a = VSWR, REACTANCE NOT TUNED OUT
WHERE b > 1, b = VSWR, REACTANCE TUNED OUT
X
SWR (REACTANCE NOT TUNED OUT)
R
$Z_0$
R
SWR (REACTANCE TUNED OUT)

**FIG. 2—Circle diagram is used to obtain reactance from two standing-wave ratio measurements, or equations can be used**

tuned out. One of the two points at which this circle crosses the real axis represents the resistive component of the unknown impedance. By projecting vertically upward or downward from this point until the larger circle, which corresponds to the swr of the unknown impedance with its reactance not tuned out, is reached, the point on the complex plane representing the unknown impedance is obtained. The vertical distance from the real axis gives the reactance of the unknown.

As there is a question as to whether to go upward or down-

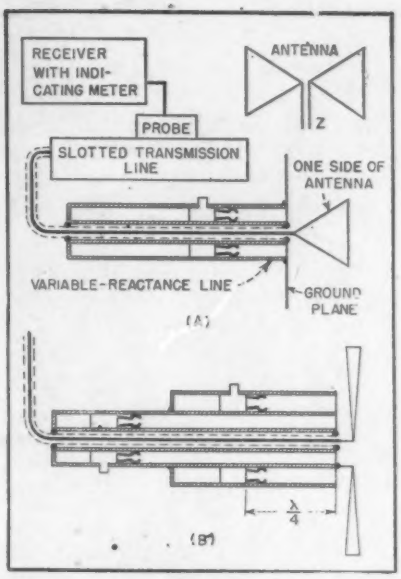



**FIG. 3—The method of Fig. 1 can be used to measure unbalanced antennas by feeding energy to the system by radiation to the antenna (A). Balanced impedances can be measured using a double-section variable reactance line (B)**

ward, or what is the same thing, whether the sign of the unknown reactance is positive or negative, the rough position of the plunger must be noted. If this plunger is less than a quarter wavelength from the load end of its line an inductive reactance is being used to tune out the reactance of the unknown, so the unknown reactance must be negative. If the plunger is more than a quarter wave but less than a half wave from the open end, the unknown reactance is positive. For making this check on sign as well as for other uses of this variable-length coaxial line, it is convenient to place callibration marks along the line, labeling the frequencies at which different plunger positions are a quarter wavelength from the end of the line.

### Sequence of Measurement

Summarizing the above, the procedure to follow in a measurement is to:

(1) Short-circuit the variable-length transmission line and measure the swr of the unknown.

(2) Also short-circuit the un-

known and find the position of a minimum on the slotted line.

(3) Remove both of the above short circuits and adjust the plunger until the minimum of the slotted line is either at the same point as it was in step 2, or if this is impossible, until it is 90 degrees away on the slotted line. In the latter case there will be two positions of the plunger that will give a minimum. One of these two minimums is much lower than the other and occurs with the plunger at a quarter wave point, at which position it is throwing a parallel resonant circuit in series with the unknown, essentially open-circuiting it. The other plunger position giving a minimum should be used.

(4) Take the standing wave ratio.

(5) Determine the resistive component of the unknown, which is the characteristic impedance of the slotted line either multiplied or divided by the standing wave ratio of step 4 depending upon the position of the minimum of step 3.

(6) Determine the reactance of the unknown from a transmission line chart, using the knowledge of the resistive component and swr of the unknown impedance, or determine it from the formula of Fig. 2 which is derived from the geometry of the circle diagram.

(7) Note the sign of the reactance from the position of the plunger in step 3.

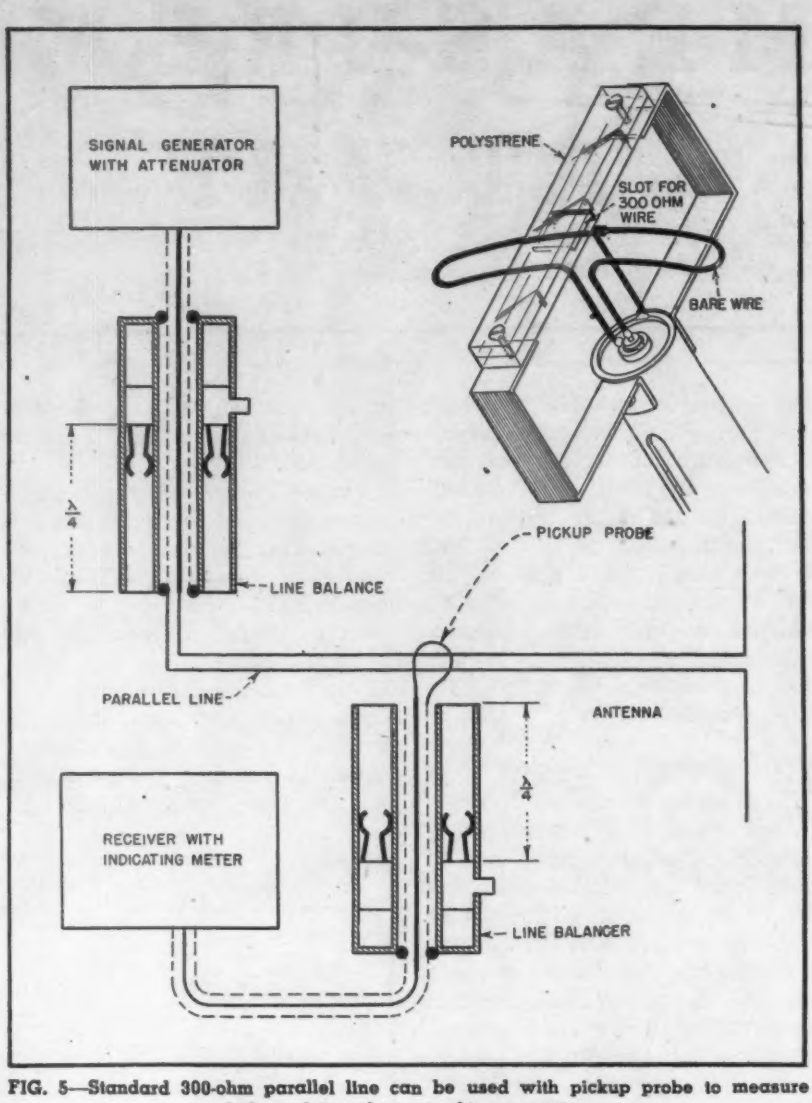



**FIG. 5—Standard 300-ohm parallel line can be used with pickup probe to measure balanced impedance in this connection**

### Measuring Balanced Impedances

The equipment arrangement as shown in Fig. 1 can be used only for measuring the impedance of unbalanced circuits, that is, circuits in which one side is grounded or can be grounded without disturbing the impedance of the unknown. If a balanced antenna, the impedance of which is to be measured, can be cut in two and half of it mounted above a ground plane as in Fig. 3A, the impedance as measured with the equipment arrangement shown will be half the impedance of the balanced antenna in both its resistive and reactive components.

An arrangement as shown in Fig. 3B could, of course, be used directly to measure balanced impedances.

Figure 4 shows a variable reactance that has been used very successfully for impedance measurements. It is constructed of two concentric brass tubes with a variable-

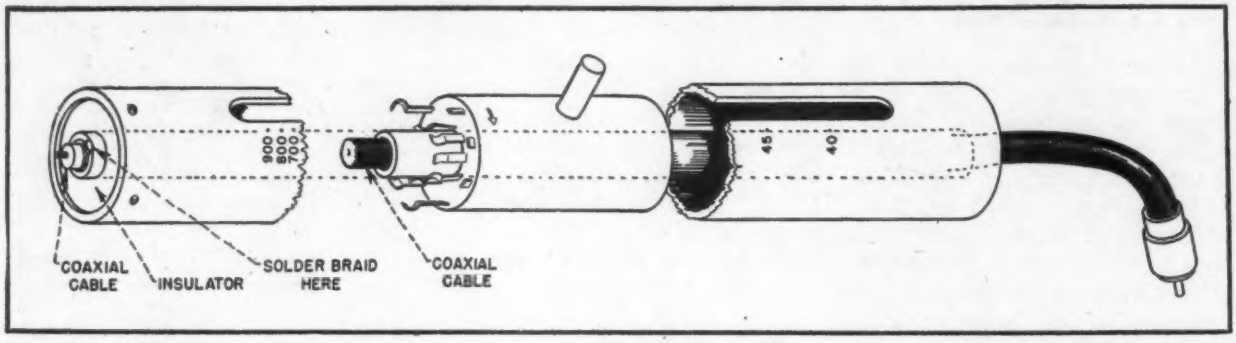



**FIG. 4—Variable reactance shown in diagrams is constructed from coaxial cable over which brass tubing is fitted**

position plunger short-circuiting the two together. A piece of coaxial cable is run through the center tube and its braid is soldered to this tube at the open end of the large coaxial line so formed. The length of the variable reactance must be at least a half wavelength at the lowest frequency at which it is to be used.

Another method of measuring balanced impedances, which requires no expensive special equipment and which gives quite accurate results, consists of stretching tautly a piece of 300-ohm parallel line between the impedance to be measured and a line balancer which may be one of the variable reactances of Fig. 4 with the plunger set at a point 90 degrees from the open end, and moving a pickup probe along the parallel line in order to measure swr.

Figure 5 shows a pickup probe fastened to the end of a second line balancer. If the signal generator used is not balanced and is not connected to the parallel line through a balancer, or if the pickup probe is not balanced, the results obtained will be so erratic as to be useless. Available polyethylene extruded parallel line seems to be sufficiently uniform along short lengths and to have sufficiently low losses and radiation up to 216 megacycles to give good results when impedance is computed from a measured swr and a measured minimum position.

Impedance measurements using either the two swr measurement with an unbalanced unknown or the 300-ohm parallel line with a balanced unknown can be made to an accuracy of 15 percent in both resistance and reactance for swr up to ten to one, and more accurately for lower swr.

### Phase Measurement

The design and adjustment of antenna arrays can be facilitated immeasurably if suitable phase measuring equipment is available. A system for measuring phase in the 44-216 mc region, an adaptation of a method used at lower frequencies for a long time[1], is illustrated by the equipment arrangement of Fig. 6. This method uses the principle that the only variation between signals taken from various points of a slotted line perfectly matched to a load is one of phase, and that phase change is linear with distance as measured along the line.

In this system the output of a signal generator is connected to both a slotted line and the device under test, such as the antenna array. The slotted line is terminated in a matched resistance so that the amplitude of current along the line is constant. A sampling probe at the end of a balancer, similar to that described for measuring swr on the open parallel line, is connected through an attenuator to the sliding pickup of the slotted line.

A receiver is also connected through a flexible coaxial line to this same slotted line pickup probe in such a way that the receiver input is the sum of the signals extracted from the slotted line and brought into the sliding probe from the sampling probe. Because of this connection, the attenuator can be adjusted so that the signal sampled from, say, a dipole in the array under test is of the same amplitude as that removed from the slotted line. The position of the slide on the slotted line can be adjusted so that the phase of the signal from the slotted line is such that cancellation of the signal from the antenna dipole under test occurs.

If the balanced probe is then moved so as to sample energy from a different dipole and the position of the sliding probe is moved to that now required for cancellation, the amount it is moved along the slotted line gives the phase difference between the two dipoles. From a knowledge of the wavelength in the slotted line this difference can be expressed in degrees.

With this equipment arrangement, a minimum point is found along the slotted line every wavelength rather than every half wavelength, as in the case in swr measurements. This difference does not mean, however, that the slotted line has to be twice as long because the sampling probe can be rotated 180 degrees if the minimum tends to fall out of range of the slotted line.

The accuracy with which phase can be measured by this method de-

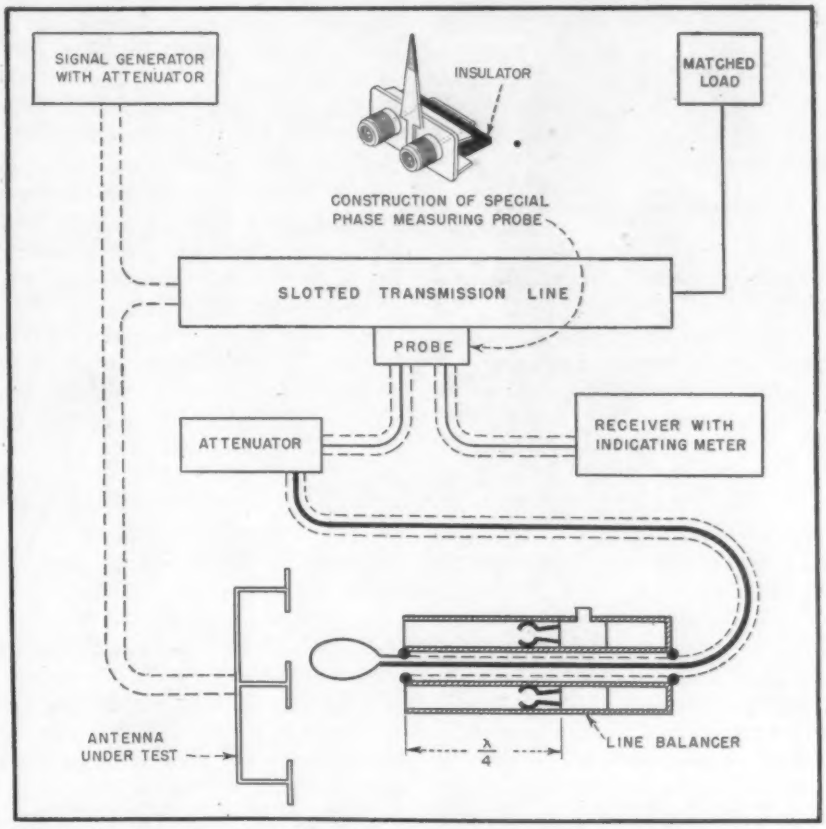



**FIG. 6—Phasing of antennas in an array can be measured by utilizing the linear phase shift with distance along a flat slotted transmission line by this connection built about a special probe**

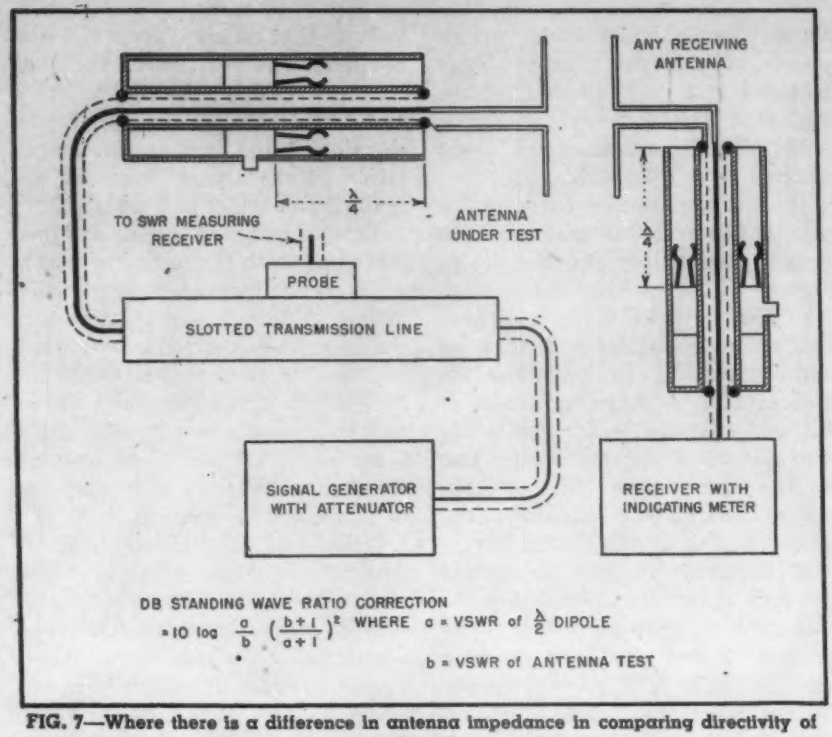

ANY RECEIVING ANTENNA
TO SWR MEASURING RECEIVER
λ/4
ANTENNA UNDER TEST
PROBE
SLOTTED TRANSMISSION LINE
SIGNAL GENERATOR WITH ATTENUATOR
RECEIVER WITH INDICATING METER
DB STANDING WAVE RATIO CORRECTION
= 10 log a/b ((b+1)/(a+1))² WHERE a = VSWR of λ/2 DIPOLE
b = VSWR of ANTENNA TEST

**FIG. 7—Where there is a difference in antenna impedance in comparing directivity of two antennas, correction can be made based on standing-wave ratio measurements**

pends largely upon how good the slotted line is and how well it is terminated. A slight rotation of the sampling probe is of no importance as it does not normally change the phase, but only the amplitude of the picked up signal. An accuracy of measurement of between ± 3 and ± 5 degrees has been consistently obtained over the 44 to 216 megacycle range.

### Antenna Gain Measurement

There are many different manners in which antenna gain (directivity) has been measured[2,3]. Results of such measurements can be expressed in terms of the directivity of a half-wave dipole or an isotropic (completely nondirectional) radiator. The latter is used in expressing absolute gain of antenna arrays. The gain of a half-wave dipole over an isotropic radiator is 2.15 db along the centers of its major lobes.

Figure 7 illustrates an arrangement of equipment for measuring the gain of an antenna over that of a half-wave dipole quite accurately and simply. In this arrangement a signal generator is connected through a slotted line and a line balancer to the antenna under test. A signal is radiated from this antenna to a receiving antenna which is connected through a balancer to a receiver.

It is necessary that both antennas be balanced carefully in order to be sure that no currents flow on the outsides of the coaxial lines leading to the signal generator and receiver. If currents do flow on these lines, they will radiate from line to line or from line to antenna and make the readings meaningless.

It is also necessary that the signal generator have an output impedance equal to the characteristic impedance of the slotted line, as will become apparent later. Because most signal generators have low output impedances, it may be necessary to connect a resistance in series with the generator output or otherwise modify the generator to obtain the required output.

With the equipment arranged as described, the signal generator attenuator should be set to such a value that a convenient output from the receiver is obtained. The antenna under test is then replaced with a half-wave dipole, not necessarily of the same impedance as the antenna under test or even a known impedance. The signal generator attenuator must then be reset until the receiver output becomes the same as it was when the antenna being tested was in use. The db difference between the two attenuator settings gives the antenna gain over a half-wave dipole, if the two antennas had exactly the same mismatches to the slotted line. The swr of the two antennas can then be measured and the ratio of the power transmission coefficients computed from the two swr values. The absolute gain of the antenna under test can then be computed as the sum of 2.15 db, the difference of signal generator attenuator settings in db and the ratio of power transmission coefficients of the two antennas expressed in db. Figure 7 gives the formula for this last quantity in terms of the two measured swr.

### Conclusions

The measuring methods herein described lend themselves quite well to quick changes of frequency, even over several octaves, as is desirable for broad-band antenna work. The accuracy seems sufficiently good for most engineering purposes. There is still an ever increasing need for a piece of high-frequency impedance measuring apparatus that approximates the ohmmeter in its simplicity of operation. At present when a change is made in, say, a television antenna, it may be necessary to measure its impedance over the entire frequency range 44 to 216 megacycles to determine if the change is desirable. This measurement is obviously a time-consuming procedure.

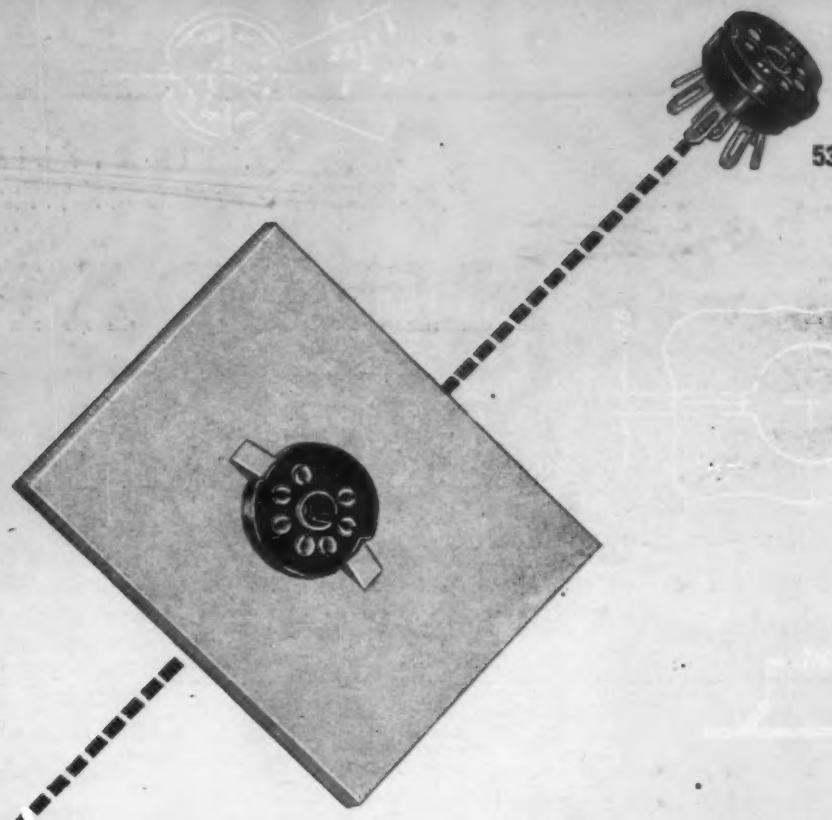
In the setting up of a new development program there is always the problem of what fraction of the available time should be spent in constructing test equipment and what fraction of the time spent using it. The best solution to this problem as applied to antenna development may eventually result in much more convenient methods of impedance measurement. Increased accuracy is, of course, always to be desired.

### References

(1) J. F. Morrison, A Simple Method of Observing Current Amplitude and Phase Relations in Antenna Arrays, *Proc IRE*, p 1310, Oct 1937.

(2) J. C. Schelleng, C. R. Burrows, and E. B. Ferrell, Ultra-Short-Wave Propagation, *Proc IRE*, p 427, March 1933.

(3) F. M. Colebrook and A. C. Gordon-Smith, The Design and Construction of a Short-Wave Field-Strength Measuring Set, *Jour IEE*, p 388, 84, 1939.

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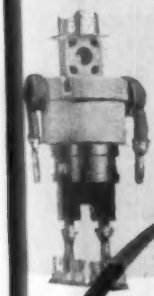

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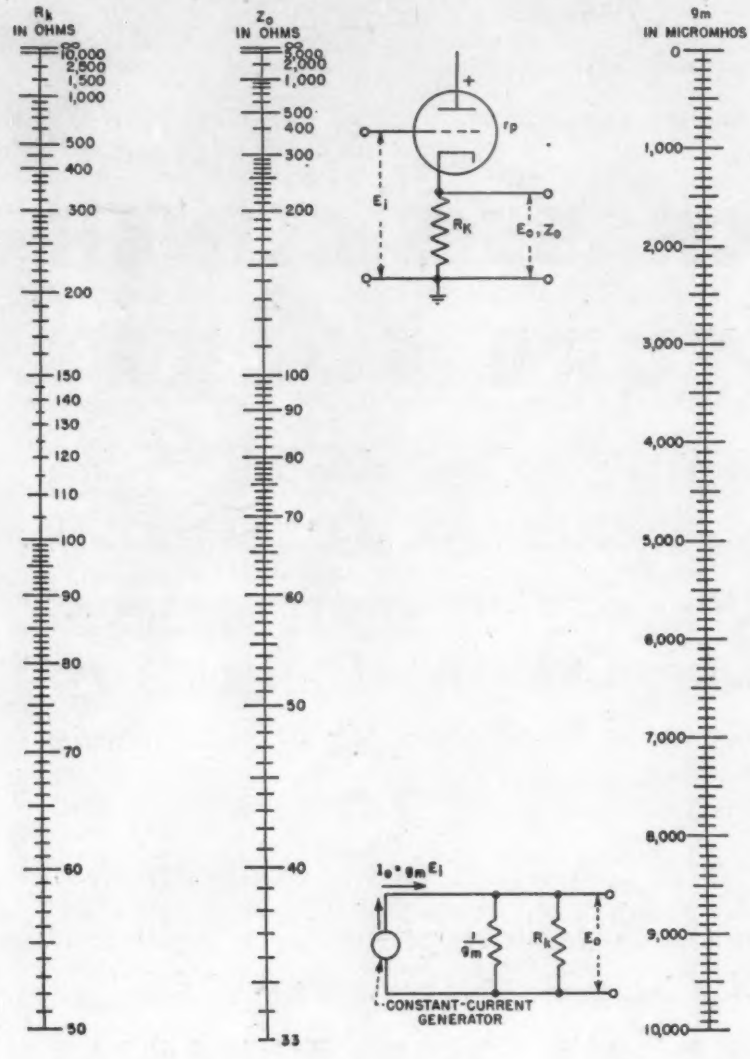
# Cathode Follower IMPEDANCE NOMOGRAPH

**Output impedance, transconductance, and cathode load resistance are related in this last of a series of three nomographs dealing with design of cathode-followers**




THE OUTPUT IMPEDANCE of a cathode-follower is readily found with the aid of the accompanying nomograph if transconductance and cathode load resistance are known. The pertinent design equation is obtained by starting with the relation for gain in terms of transconductance. When $R_k << r_p$

$$A = \frac{E_o}{E_i} = \frac{g_m R_k}{1 + g_m R_k} \qquad (1)$$

Rewriting gives

$$E_o = \frac{(1/g_m)\, R_k}{(1/g_m) + R_k} g_m E_i \qquad (2)$$

This represents a parallel resistance combination consisting of two resistances, $1/g_m$ and $R_k$, through which flows a current $g_m E_i$, as indicated in the constant-current form of the equivalent circuit on the nomograph.

Equation 2 states that the output voltage $E_o$ is a result of an output current ($I_o = g_m E_i$) flowing through an output impedance

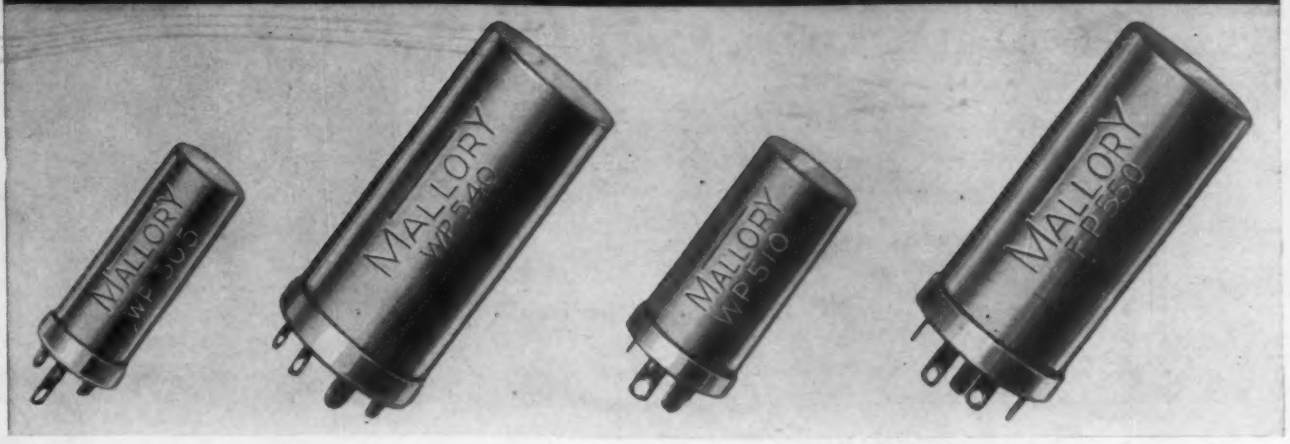
$$Z_o = R_k/(1 + g_m R_k) \qquad (3)$$

This $Z_o$ is the output impedance of the cathode-follower as given by the nomograph.

This chart should be of particular value in providing the proper termination for transmission lines and coaxial cables.

In preceding issues, a general cathode-follower nomograph related gain, amplification factor, and the ratio of cathode load resistance to tube plate resistance, and a nomograph for pentodes related gain, transconductance, and cathode load resistance.

# Special Television Capacitors by MALLORY




Experimental television requirements indicate a need for certain electrolytic capacitor ratings involving special impedance values.

The units listed below are designed especially for these applications, and where special impedance values are required, they are rated in impedance (Z) rather than in capacity. Note that the maximum impedance rating in the chart is coupled with the frequency at which this rating is obtained.

Type WP520 may be used for bypassing in the audio, and synchronizing amplifier stages, and also for bypassing the deflecting amplifier cathodes.

Type FP550 is suggested for filtering the low voltage power supply. Note that the 10 mfd. 450-volt section is designed as the input and the 80 mfd. 400-volt section as the output.

Type WP505 is designed for the Video amplifier cathode bypass and is rated at 3 volts non-polarized. The impedance rating of 10 ohms is used in place of a capacity value, since this is the important characteristic. The 10-ohm value refers to the 30-cycle characteristic, the impedance of course being lower at the higher frequencies.

Type WP510 is suggested for the horizontal centering control bypass. It is rated at .5 ohms impedance rather than as a capacity value. The .5 ohm rating is at 15750 cycles and is the Mallory final inspection limit.

Type WP540 is intended for bypassing the vertical centering control and is rated at 1.0 ohm impedance at 60 cycles.

All impedance values mentioned above are the maximum passing limit at the Mallory final inspection department. Actual values normally run considerably lower than the rated impedance.

**SPECIAL TELEVISION CAPACITORS—TYPE FP AND WP**

| Capacity or Impedance | Wkg. Volts | Mallory Catalog Number | Size D | Size H | Maximum Surge Voltage | 120 Cycle Ohms | DC Ma | Capacity Tolerance % − | Capacity Tolerance % + | 120 Cycle Ma Ripple | Temp. Range C° − | Temp. Range C° + |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40-40-40 | 25DC | WP520 | 1 | 2 | 40 | 7. | .7 | 10 | 100 | 55* | 20 | 85 |
| 10 | 450 DC | FP550 | 1⅜ | 3 | 525 | 24. | .7 | 10 | 50 | 150 | 10 | 65 |
| 80 | 400 DC | | | | 475 | 3. | 1.8 | 10 | 50 | .... | 10 | 65 |
| 10Z @ 30 cycles to 5 megacycles | 3NP | WP505 | ¾ | 2 | 4 | .... | .5 | .... | .. | .... | 20 | 85 |
| .5Z @ 15750 cycles | 3NP | WP510 | 1 | 2 | 4 | .. | 1.0 | ... | .... | ... | 20 | 85 |
| 1.0Z @ 60 cycles | 3NP | WP540 | 1⅜ | 3 | 4 | .4 | 3.0 | 10 | 100 | .... | 20 | 85 |

* Ripple current refers to 1st section only.

*Note — This ad is a copy of page 16 of the Mallory Dry Electrolytic Capacitor Catalog... Write for a copy*

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# TUBES AT WORK

## Including INDUSTRIAL CONTROL

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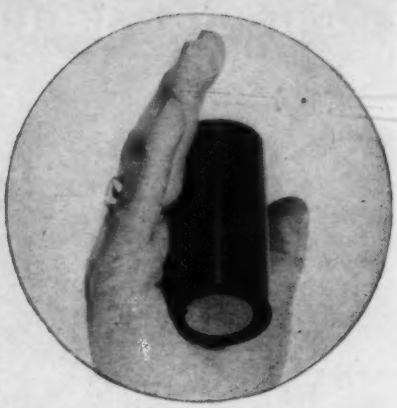


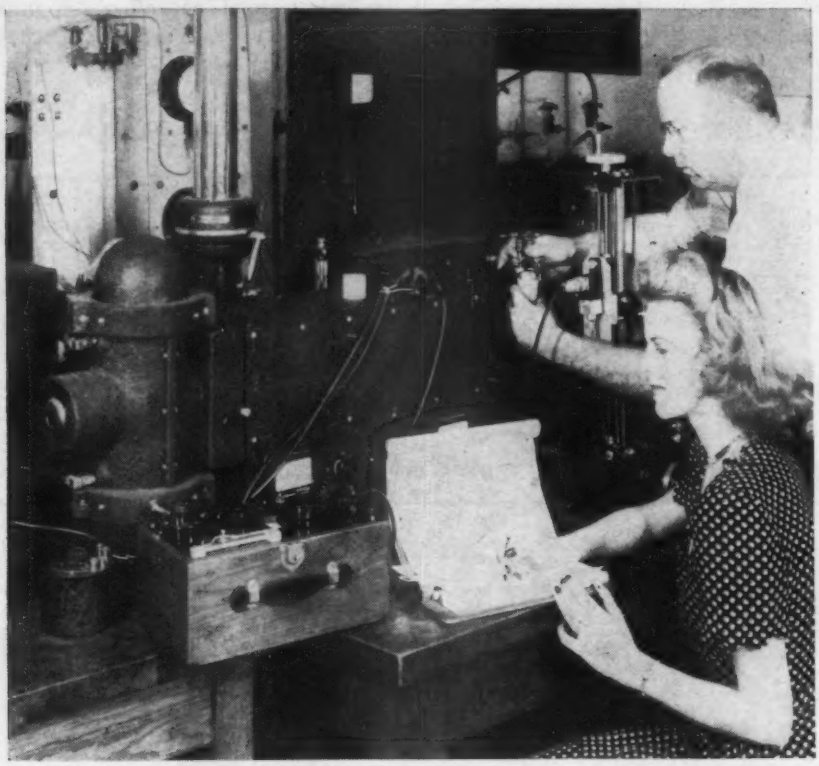
Bakelite-encased rock sample into which the tracer is injected for x-raying. Developed by Gulf Research Laboratories, the x-ray technique shows the behaviour of the entire stratum from which the sample was taken

### X-Rays Predict Oil Field Flow

TO HELP solve the riddle of how oil flows through sand and rocks under an oil field, and how it is affected by underground water and gas, an x-ray method of studying a sample taken from a drill hole has been developed by Gulf Oil Corporation.

A small three inch by one inch sample, or core, from the drill hole is used. In effect, the core is made to reproduce in miniature the layer of rock or sand from which it was taken. Study of the reactions in the sample gives a picture of flow conditions in a stratum perhaps hundreds of feet thick and miles wide.

The core is subjected to artificial pressures and saturations of oil, gas, and water. The progress of these elements in the core is gaged by an x-ray unit called "apparatus for determining permeability-saturation." The x-ray beams follow the reaction by means of an opaque tracer mixed with the liquid or gas. The tracer causes variations in intensity of the beams as they pierce the core, indicating the extent of saturation. A similar technique is used in x-raying organs of the human body filled with opaque barium.



This x-ray unit focuses on a sample of oil-well rock into which fluids found underground are injected. From the resulting radiograph, forecasts can be made of how oil, gas, and water will flow through rock strata far below the surface

A basis for comparison is established by studies of the core at 100 percent and at zero saturation. Then an extensive series of flow experiments, reproducing conditions which might be created by various recovery methods, must be run through. The effects of gravity, capillary attraction, and the amounts of oil, gas, and water already in the sand are charted. These procedures are sometimes repeated on as many as 10 or 11 cores taken from the different layers through which the well extends.

By correlating such data, it can be determined how natural pressure, artificial gas injection, or water flooding will move oil toward well shafts through various strata of the field being studied. Methods of working the field can be planned accordingly to assure the greatest yield, and extent of yield forecast.

Permeability - saturation studies are useful in indicating whether injected gas can move oil through the strata at varying degrees of water saturation. The method also aids the operator in minimizing the escape of injected gas through nonproductive formations. The x-ray technique will also be used to explore the possibilities for salvaging more oil from abandoned wells.

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If you make time-frequency measurements or if you operate two or more independent systems synchronously, the new Western Electric Primary Frequency Standard is the instrument you need.

Designed for 100 kc operation, its accuracy is rated conservatively at *one part per $10^8$ per day,* regardless of moderate changes in ambient temperature, air pressure and humidity. Actual tests in a government laboratory, however, have indicated a frequency variation of *only 1.4 parts per $10^9$ per day* . . . which corresponds to *less than 1½ cycles at 1,000 megacycles.*

With such a high degree of accuracy, you would hardly expect this new Primary Frequency Standard also to be . . . (1) small and compact . . . (2) light in weight—only 90 pounds . . . (3) exceptionally rugged . . . and (4) moderate in cost...*but it has all of these advantages too.*

Check these points of superiority against the frequency source you are now using or contemplate purchasing, then get complete information by calling your nearest Graybar representative or writing to Graybar Electric Company, 420 Lexington Avenue, New York 17, N. Y.

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OFFICES IN 95 PRINCIPAL CITIES

*—Quality Counts—*

# Western Electric

bfo operating for c-w reception is made possible in the National NC-173 by the isolation of the avc system from the c-w oscillator.

With more common receiver designs the avc system is arranged so that it is turned off automatically when the bfo is turned on. Alternatively, if the avc is separately controlled, the bfo produces a large avc voltage, making the receiver very insensitive and producing full-scale S-meter deflection, so that the avc must be turned off to use the receiver.

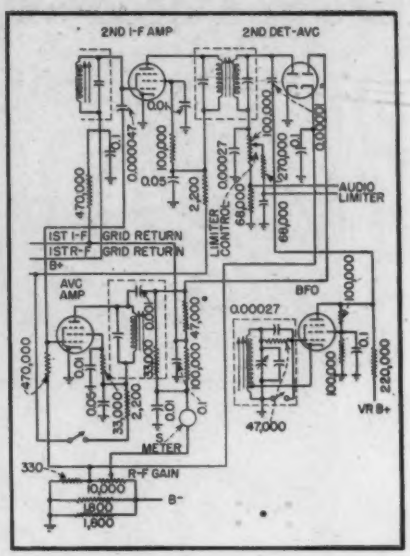
In the NC-173, the avc system is isolated from the bfo by shielding and by circuit arrangement. The method used is to take some of the second i-f amplifier grid voltage and amplify it in a separate high-gain 6AC7 stage, and apply the amplified voltage to half of a 6H6 rectifier to produce avc voltage. The bfo output voltage feeds in to the second detector in the usual manner. This arrangement isolates the two circuits because the bfo voltage cannot feed backward through the second i-f amplifier tube and, therefore, does not get into the avc system.

As in most receivers, the signal-strength meter is actuated by the avc system so turning the bfo on or off does not change either the signal strength meter reading or receiver gain. The avc voltage is applied to the r-f stage and both i-f stages, which produces good avc action. The system is very effective because increasing signal level reduces the gain of the second i-f stage without affecting the amount of avc voltage produced. Similarly, this system is effective because the avc voltage does not reduce the gain of the 6AC7 avc amplifier.

*S Meter Circuit*

As shown in the diagram, the signal strength meter is placed in a diode rectifier circuit. The meter scale is calibrated in S units from 1 to 9 with roughly 5 db per S unit, and in db above S9 from 0 to 40. S9 corresponds to approximately 50 microvolts. This arrangement permits signal strength measurements from roughly 0.5 to 5,000 microvolts. The S meter, therefore, gives readings for approximately an 80-db range of signal inputs.

The 80-db reading on the S-meter scale corresponds to approximately a 20-db change in current through the meter. This indicates that with an 80-db increase in input the avc system reduces the gain of the first r-f and first i-f stages by 60 db, so that a net increase of 20 db reaches




Circuit of the avc system and bfo of the National NC-173

the S meter. Reference to the transconductance versus grid bias curves for the 6SG7 tube shows that this is not at all difficult.

Similarly, these curves indicate that the second 6SG7 i-f amplifier gain can be reduced approximately 20 db to compensate for the 20-db increase in signal on its grid, thus resulting in good avc action on the signal reaching the detector.

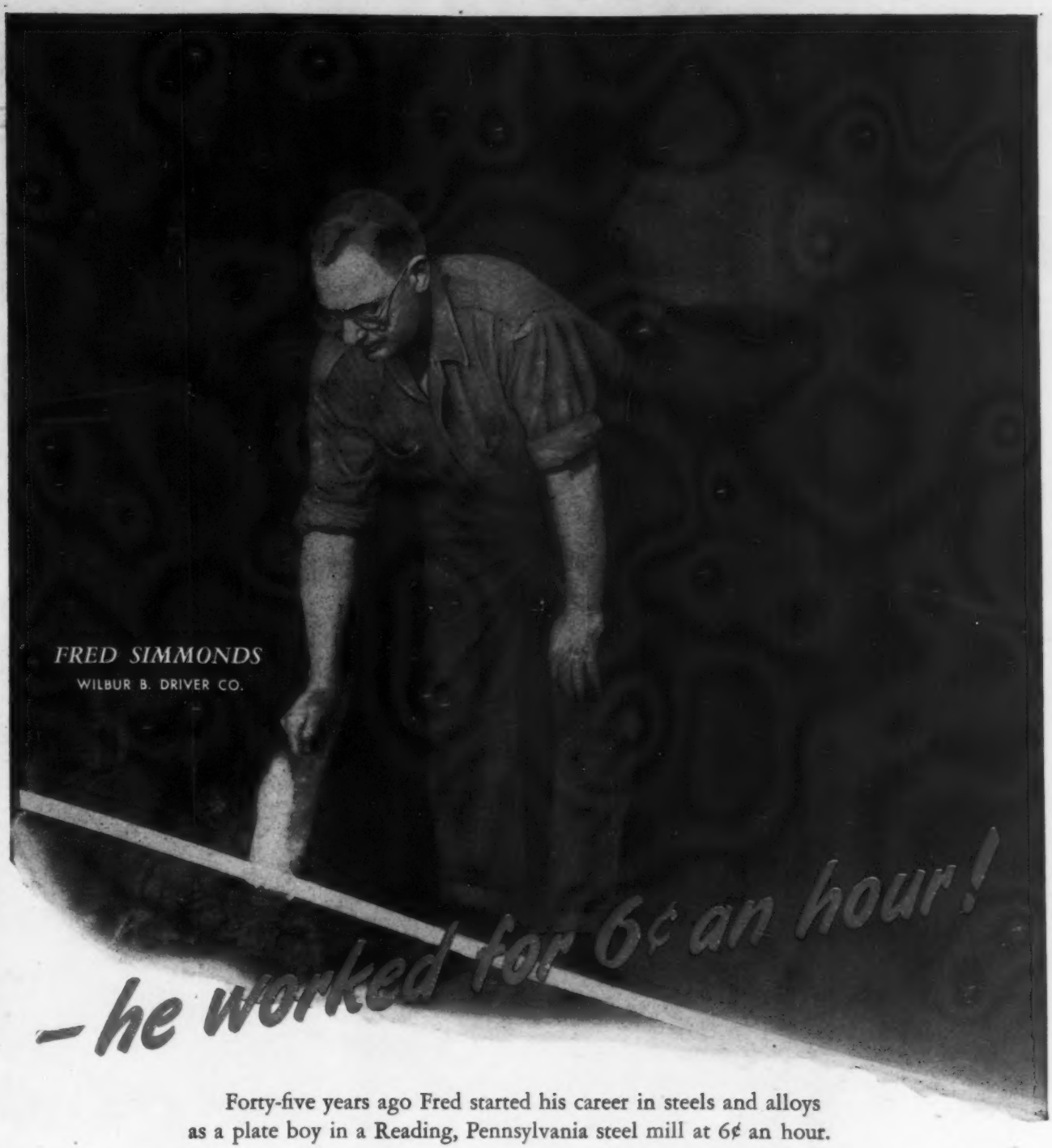
The avc system actually handles signal variations of more than 80 db above its threshold without overload, even though off-scale deflection of the S meter is obtained. The S-meter sensitivity is controlled by the r-f gain control. Retarding the r-f gain control decreases S meter sensitivity. The S meter zero setting does not require readjustment due to the diode rectifier meter circuit.

The i-f transformers are the permeability-tuned low-impedance type. The tuning cores are arranged so that gain and selectivity do not change appreciably as the cores are moved for tuning. The low-impedance type transformer requires relatively large tuning capacitors and as a result changes in associated circuit capacitance caused by changing tubes, or tube capacitance variation due to heat or avc voltage, all have a minimum detuning effect. This type of i-f transformer also reduces stray couplings, with the result that sides of the i-f curve do not flare out as quickly off resonance

(continued on p 148)

## LARGE-SCREEN COLOR TELEVISION

Three-color projector developed by RCA Laboratories for pictures on a 7½ by 10 foot screen and recently demonstrated in Philadelphia. At right are the elements of the reflective system fed by three projection-type cathode-ray tubes used for simultaneous color transmission (ELECTRONICS, p 140, Dec. 1946)




Forty-five years ago Fred started his career in steels and alloys as a plate boy in a Reading, Pennsylvania steel mill at 6¢ an hour.

Today, Fred is Hot Mill superintendent for Wilbur B. Driver Co., one of many men in our organization who have devoted their active life toward the production of better resistance alloys for industry.

The fact that Wilbur B. Driver alloys are widely accepted throughout the world—in electric heating, and for instrument and electronic applications—is a tribute to the purpose and accomplishment of these men.

**WILBUR B. DRIVER CO.**
**150 RIVERSIDE AVE., NEWARK 4, NEW JERSEY**

# THE ELECTRON ART

Edited by FRANK ROCKETT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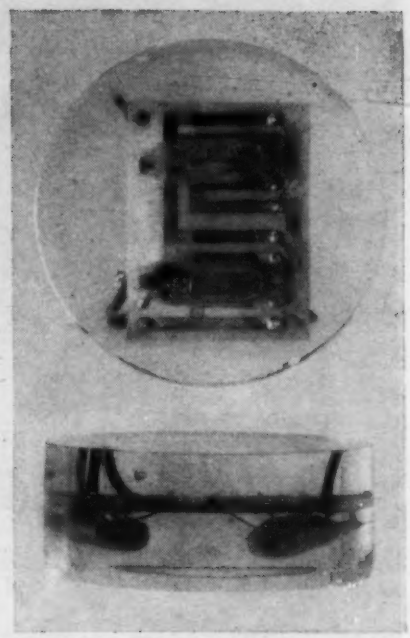
## Stabilizing Electrical and Mechanical Characteristics Of Circuits

EXACTING REQUIREMENTS of such wartime electronic equipment as radio proximity fuzes necessitated potting the circuit components in a casting resin. An investigation of such resins was conducted at the National Bureau of Standards with the development of a material with low electrical loss and high mechanical rigidity, and with such viscosity that it would fully penetrate the equipment during potting. The new resin is particularly suitable for potting because of its very low shrinkage during gelling, thus it does not subject components to high pressure as do most such materials.

### *High-Frequency Resin*

The casting resin for use in high-frequency high-impedance circuits has low power factor (about 0.0006 at 100 mc), low dielectric constant (2.5 at 100 mc), short polymerization period at low temperature and atmospheric pressure, high impact strength, small volume shrinkage on polymerization, dimensional and electrical stability, and low moisture absorption (0.01 percent after 24-hour immersion). In addition, this NBS Casting Resin has low viscosity and low surface tension so that it penetrates small openings; it has a dielectric strength of about 630 volts per mil (measured on a $\frac{1}{8}$ inch sample) and a volumetric resistivity over $10^{17}$ megohms per cubic centimeter. The cured resin can be machined.

In potting equipment that includes vacuum tubes with glass envelopes, protection from thermal

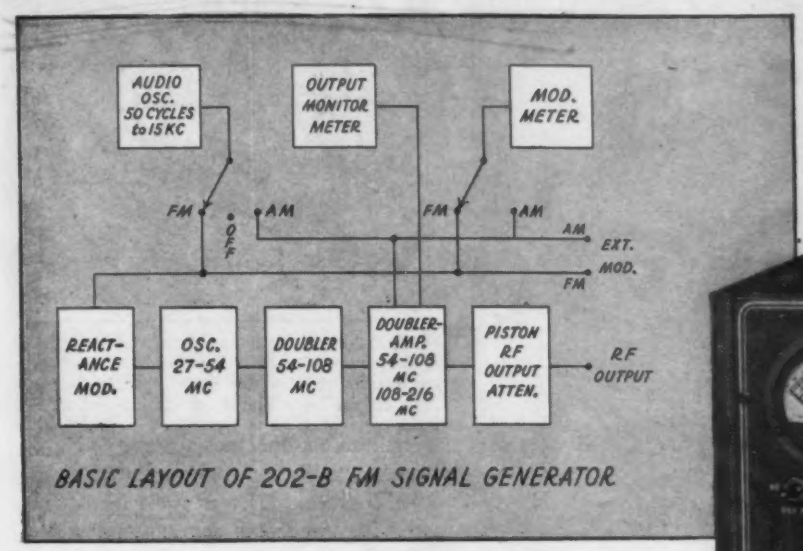


Circuits can be suspended within the casting resin by first allowing a portion of the resin to gel, after which it will support the circuit. The mold (glass or metal) is then completely filled. Printed and subminiature circuits intended for industrial or portable use can be protected from damage by potting

Potting, or embedding, high-frequency high-impedance electronic circuits can be readily done using NBS Casting Resin

This subminiature printed plug-in multistage electronic industrial control unit (about 2.25 inches in diameter) is potted to provide mechanical-electrical stabilization

# THE NEW FM SIGNAL GENERATOR




BASIC LAYOUT OF 202-B FM SIGNAL GENERATOR

## FREQUENCY RANGE 54 to 216 MEGACYCLES

## Model 202-B

Shown above in block form are the basic circuit elements of the new 202-B FM Signal Generator. The stage following the RF oscillator, in addition to doubling the oscillator frequency, prevents interaction between the output stage and the oscillator and modulator circuits. It also provides sufficient drive to saturate the output stage thereby minimizing unwanted amplitude modulation. The FM and AM modulating systems are independently monitored by a modulation meter which may be switched to indicate the degree of each type of modulation present.

Frequency doubling at the final stage is accomplished by changing the point at which the output tank coil is grounded, assuring stable and trouble free range switching.

## *THE* Signal generator to help solve your FM problems

In response to widespread demands for a suitable FM Signal Generator to cover the new FCC frequency allocations, Boonton Radio Corporation now offers the Type 202-B FM Signal Generator to provide the utmost in performance. FM and television engineers will welcome the 202-B Signal Generator as *the* essential laboratory instrument for receiver development and research work.

**Frequency coverage from 54 to 216 megacycles is provided in two ranges, 54 to 108 megacycles and 108 to 216 megacycles. A front panel modulation meter having two deviation scales, 0-80 kilocycles and 0-240 kilocycles, permits accurate modulation settings to be made.**

**Although fundamentally an FM instrument, amplitude modulation from zero to 50%, with meter calibrations at 30% and 50%, has been incorporated. This AM feature offers increased versatility and provides a means by which simultaneous frequency and amplitude modulation may be obtained through the use of an external audio oscillator.**

**The internal AF oscillator has eight modulation frequencies ranging from 50 cycles to 15 kilocycles, any one of which may be conveniently selected by a rotary type switch for either amplitude or frequency modulation.**

**The calibrated piston type attenuator has a voltage range of from 0.1 microvolt to 0.2 volt and is standardized by means of a front panel output monitor meter.**

**The output impedance of the instrument, at the terminals of the R.F. output cable, is 26.5 ohms.**

**Careful consideration has been given to the positioning of the main frequency dial and various controls, with modulation and output monitor meters located at eyelevel for maximum readability. Dimensions have been chosen to permit greatest economy of laboratory space. For complete details write for Catalog "D".**

*The design of this instrument was described on pages 96-101 of the November issue of ELECTRONICS. Reprints of this article are available upon request.*

**BOONTON RADIO Corporation**
BOONTON · N·J · U·S·A

DESIGNERS AND MANUFACTURERS OF THE Q METER · QX CHECKER · FREQUENCY MODULATED SIGNAL GENERATOR · BEAT FREQUENCY GENERATOR AND OTHER DIRECT READING INSTRUMENTS

After the circuit has been potted at low temperature it is placed in a curing oven. A hard surface can be produced by flooding with glycerol after initial gelation

and mechanical shock can be provided for the glass by rubber jackets. Sharp corners should be eliminated from components to be cast as strains set up at them may cause crazing. Molds in which equipment is cast can be lubricated with Silicone grease.

Electrical equipment embedded in the resin, either complete circuits or plug-in subassemblies, are well insulated as well as protected from mechanical vibration and deteriorating atmospheres. The potting technique can be used to protect industrial equipment, to stabilize portable devices (hearing aids), and to protect components from acid fumes, high humidity, and salt spray.

## Scale of N Counting Circuits


By Bradford Howland

*Rocket Sonde Section*
*Naval Research Laboratory,*
*Washington, D. C.*


Experiments have led to development of a decade counting circuit for use with such measuring equipment as the Geiger-Mueller counter. The basic Eccles-Jordan trigger circuit exhibits two stable states corresponding to conduction in either one of two vacuum tubes[1,2]. This circuit has found wide application, particularly as a scaling or counting circuit[3]. Being a two-positioned circuit, it is best adapted for counting in powers of two (the binary numerical system), and a calculation is often necessary to convert the count to the more familiar decimal number. Recently there have been developed several ingenious decade counting circuits using combinations of scale of two circuits[4,5,6,7].

### *Multiple Stable States*

If Eccles-Jordan circuits could be constructed with more than two states of stable equilibrium, still other types of scaling and counting circuits would be possible. A generalized Eccles-Jordan circuit having $N$ states of stable equilibrium, where $N$ can be any integer greater than one, consisting of $N$ tubes interconnected in symmetrical fashion is shown in Fig. 1. The interconnections are such that conduction in any one tube cuts off current in all the others. These tubes, being cut off, allow the conducting tube to

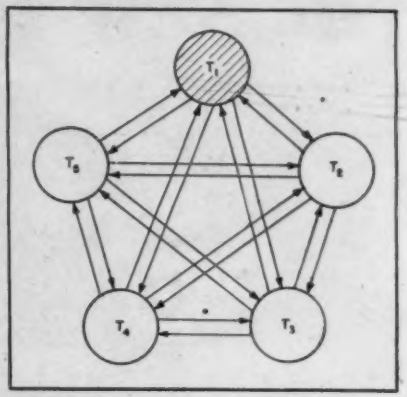



FIG. 1—Basic counter circuit consists of interconnected tubes; the number of tubes is determined by the desired scale base, the circuit here being for a base of five

continue conducting current so that the circuit is in a condition of stable equilibrium. There are $N$ such equilibrium states corresponding to the $N$ tubes.

Several types of scale of $N$ circuits can be constructed using this basic circuit, perhaps the simplest being that shown in Fig. 2, which uses multigrid tubes. Conduction in any one tube drives one grid in each of the others negative, cutting off current in them. This circuit suffers from the disadvantage that the number of sensitive grids

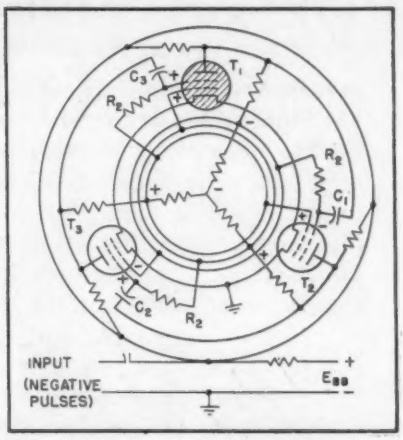



FIG. 2—A scale of three counter can be built using tetrodes

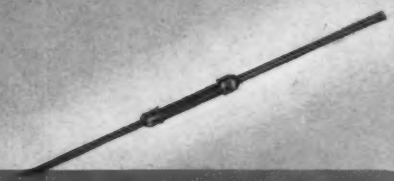
in most tubes is small, hence $N$ is severely limited.

This limitation is avoided in the diode-triode circuit shown in Fig. 3 for which $N$ is 5. The plates of the multiple diodes (actually several duodiodes) are connected to the grids of the several triodes. All grids are biased at zero volts. Conduction in any triode drives the cathode of the associated diode negative with respect to its plates

(Continued on p 174)

# When a little means a lot

Whenever and wherever space is at a premium . . . in shavers, hearing aids, pocket radios, guided missiles and other radio, electrical or electronic devices . . . you can use one or more of these four miniature products IRC makes-by-the-million. For complete information, including dimensions, ratings, materials, construction, tolerances, write for comprehensive catalog bulletins, stating products in which you are interested.



## MPM Resistors

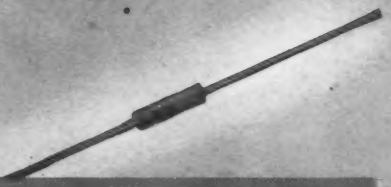
¼ watt for UHF. Resistance film permanently bonded to solid ceramic rod. Length only 9/16". Diameter 1/10". Available resistance values 30 ohms to 1.0 megohms.

## TYPE H Fingertip Control

Composition volume or tone control. Its 13/16" diameter and ½" overall depth include knob and bushing.

ILLUSTRATIONS ACTUAL SIZE

I = 1/IRC



## BTR Resistors

⅛ watt—insulated composition. Length only 13/64". Diameter 3/32". Resistance range 470 ohms to 22 megohms (higher on special orders).

## TYPE SH Fingertip Switch

Similar to TYPE H Control (left) in appearance. 13/16" diameter. OFF and 3 operating positions.

**INTERNATIONAL RESISTANCE COMPANY**

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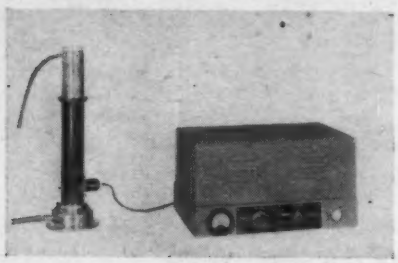
# NEW PRODUCTS

Edited by A. A. McKENZIE

**New equipment, components, packaged units, allied products; new tubes. Catalogs and manufacturers' publications reviewed.**

## Sonic Oscillator (1)

RAYTHEON MFG. CO., 178 Atlantic Ave., Boston 9, Mass. A new magnetostriction oscillator operating at 9 kc provides a means for research into living organisms and chemical



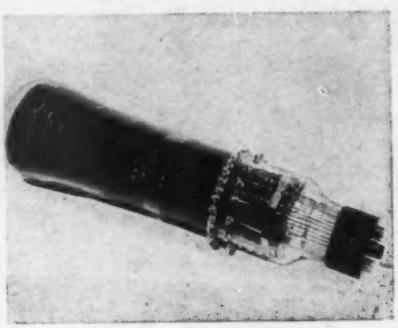
mixtures. The equipment consists of three parts—an electronic driver, a hollow vibrator column, and a cup assembly. Operation is simple and full power is obtained within a minute of connecting to the line. An illustrated bulletin is available.

## Ham 100-Watter (2)

SUPREME TRANSMITTER CORP., 280 Ninth Avenue, New York City. Model AF-100 desk type transmitter is a six-band 100-watt-output transmitter housed in a rectangular metal cabinet measuring 29⅜ x 11¾ x 18⅜ inches. It covers the 10, 11, 15, 20, 40 and 80 meter bands for cw, icw, a-m and f-m phone transmission, with frequency modulation in the 27.160 to 27.430 and 29 to 29.7 megacycle bands. The transmitter is continuously tunable throughout each band. A variable frequency oscillator followed by slug-tuned buffer and doubler stages ganged to the oscillator dial do the tuning. Band changing is accomplished in the exciter by a band selector switch and in the final stage by plugging in a coil. Power consumption is 325 watts and the approximate weight is 125 pounds.

## Eight-Gun Tube (3)

ELECTRONIC TUBE CORP., 1200 E. Mermaid Ave., Philadelphia 18, Pa. The type 7Z8P11 cathode-ray tube has been designed for special industrial and medical applications in which the registration of eight independent phenomena of transient or random natures on a single 7-inch screen is desired. The screen can be supplied in any of the standard phosphors. Voltages up to 2,000 volts for the second anode and 4,000 volts for the third anode are required.



**USING THE NUMBERS**

Readers desiring further details concerning any item listed in the New Products department can obtain the information by using the cards furnished as a stiff, colored insert elsewhere in this department.

Place the number (appearing to the right of the heading) of one item in which you are interested in a circle and then fill out the balance of the card according to directions appearing on the colored sheet. Unnumbered items listed at the end should be procured direct from the manufacturer or publisher upon payment of the fee noted.

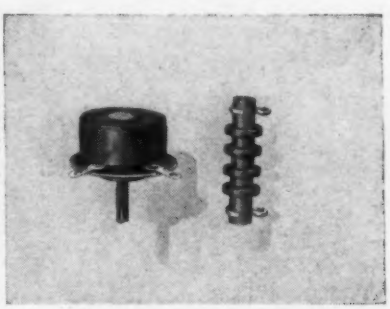
## Frequency Record (4)

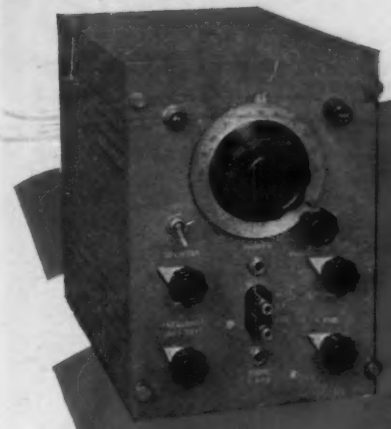
UNIVERSAL MICROPHONE CO., Inglewood 2, Calif. The well-known D61A Frequency Record used for checking the audio response characteristics of pickups and complete

lateral disc recording and reproducing systems is now offered as a 12-inch, 78-rpm Vinylite pressing. Both sides of the disc are recorded in duplicate.

## Chokes (5)

CAMBRIDGE THERMIONIC CORP., 445 Concord Ave., Cambridge 38, Mass. The type LHC iron-core r-f choke shown at the left is available in 8 standard values from 2.5 to 125 millihenrys with a current rating of 125 milliamperes. The type LAB pie-wound r-f inductor at the right will carry a maximum of 125 milliamperes and is available in types that range in inductance between





# *Visual* Alignment means *Accurate* Alignment

**Alignment with a Visual Alignment Signal Generator (VISALGEN) eliminates guess-work and time consuming plotting.**

● **WHAT** The *Visalgen* Does

Aligns intermediate and radio frequency amplifiers in FM and AM Communication and Broadcast Receivers, as well as Broadband receivers of all types.

● **WHY** The *Visalgen* Is Useful

Saves time, instantaneously you see the entire frequency response curve. Indispensable for FM discriminator and overcoupled circuit alignment.

● **HOW** The *Visalgen* Operates

Gives a wide band FM output synchronized with a linear sweep, so that the overall frequency response of the circuit under test is seen on an oscilloscope screen.

● **WHERE** The *Visalgen* May Be Used

The Visalgen, available in two models: the 205TS (500 KC to 20 MC) and the 204TS (20 KC to 500 KC) is useful in Development Laboratories, Production Testing or on the service bench. In short, wherever fast accurate alignment is necessary.

***A matching oscilloscope is also available in a separate cabinet or installed with either VISALGEN in a single cabinet.***

**IMMEDIATE DELIVERY —** HARVEY OF CAMBRIDGE **WRITE FOR FURTHER INFORMATION**

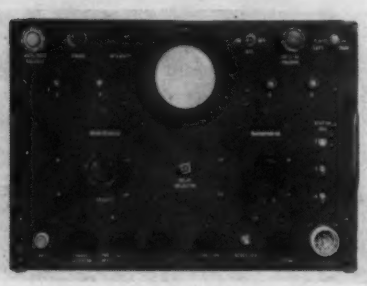
**HARVEY RADIO LABORATORIES, INC.**

439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS

0.75 and 15 millihenrys, a total of 8 standard values.

## Simplified Loran Indicator (6)

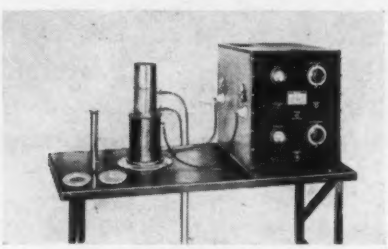
PHILCO CORP., Philadelphia 34, Pa. New equipment for taking more accurate loran navigational fixes has just been announced. The Seaguide uses new miniature tubes, contains a pulse-locking circuit, and weighs 35 pounds. It can



be supplied for 60- or 400-cycle operation and is small enough for installation in large aircraft. Two knobs with associated counters allow the navigator to set up lines of position from two pairs of transmitting stations in rapid succession and thus show a fix.

## Ultrasonic Generator (7)

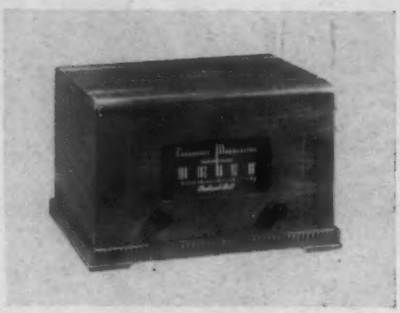
TELEVISO PRODUCTS CO., 7466 West Irving Park Road, Chicago 34, Ill. The U-300 and U-500 Ultrasons have been developed as sources of



ultrasonic energy for experiments in the superaudible region between 7.5 mc and 400 kc. A bulletin is available describing the equipment and listing a bibliography of technical references.

## F-M Tuner (8)

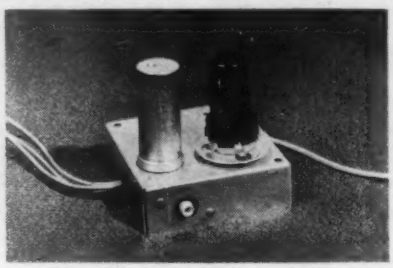
PACKARD-BELL CO., Inc., Box 3219 Terminal Annex, Los Angeles 54, Calif. A tuner unit for reception



of f-m broadcast stations can be connected to a radio-phonograph combination or any other convenient audio amplifier and loudspeaker system. The unit is designed to adapt existing broadcast receivers to reception from the new medium.

## Reluctance Pickup Preamplifier (9)

GENERAL ELECTRIC CO., Syracuse, N. Y. A preamplifier for use with the variable reluctance pickup uses a single tube and associated circuit to match the pickup output impedance to a radio receiver audio input circuit. The combination pro-



vides sufficient preamplification to play records through the receiver, at the same time giving best tone compensation.

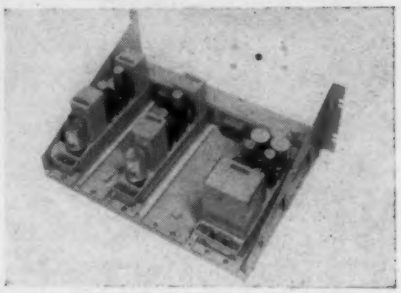
## Playback Arm (10)

GRAY RESEARCH AND DEVELOPMENT CO., Inc., Elmsford, Westchester Co., N. Y. Offset or straight playback arms are available for use with highly-compliant cartridges. The

new arms are fabricated from magnesium and have a precision ground angular-contact ball pivot. Without cartridge the arms are priced at $35.

## Plug-In Audio Facilities (11)

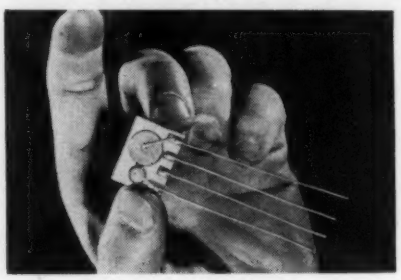
THE LANGEVIN CO., 37 West 65th St., New York 23, N. Y. The rack mount illustrated is set up for three 116A preamplifier or booster amplifier types and two 117A program or monitor amplifier types. The



plug-in construction allows equipment to be quickly removed and an identical component plugged into its place. Another feature of this broadcast equipment is that only the two equipment types and the two tube types are necessary between microphone and transmitter input.

## Interstage Coupling Unit (12)

CENTRALAB DIVISION of Globe-Union, Inc., Milwaukee 1, Wis. A new commercial application of printed electronic circuits is embodied in the Couplate. The standard unit designed to suffice for interstage coupling in over 90 percent

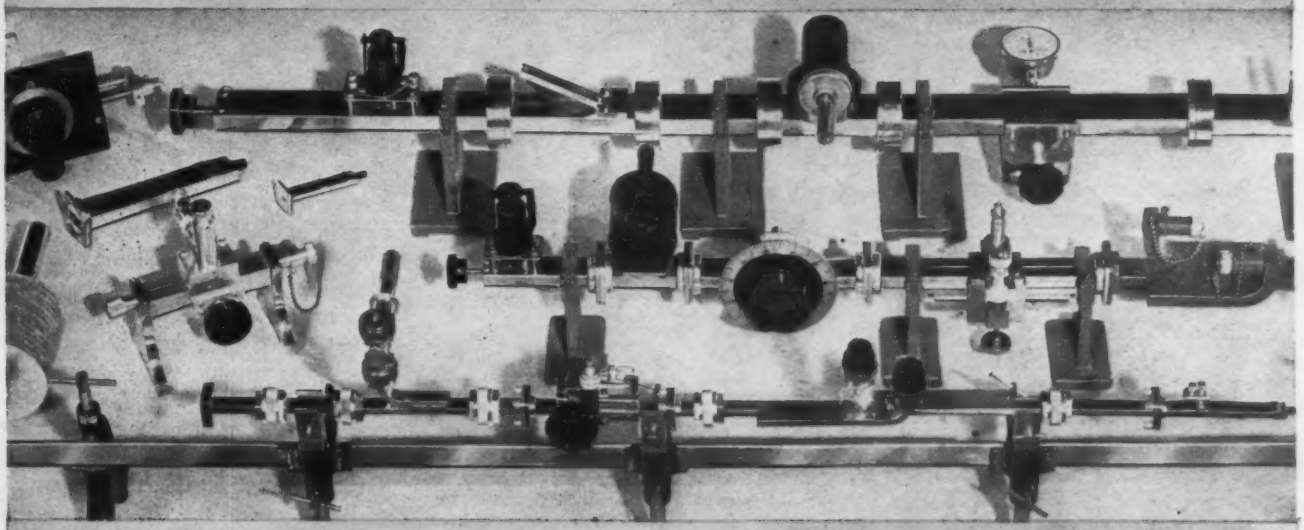


of all radio receivers now in use or production measures 1 by $\frac{3}{4}$ by $\frac{1}{8}$ inch. It comprises a coupling capacitor, 0.01 microfarad; plate r-f bypass, 250 micromicrofarads;

(continued on p 194)

# DE MORNAY · BUDD STANDARD TEST EQUIPMENT

## For Precision Measurements in the Microwave Field



The complete line of De Mornay·Budd standard test equipment covers the frequency range from 4,000 mcs. to 27,000 mcs. It provides all R. F. waveguide units necessary for delicate, precision test work requiring extremely high accuracy in attenuation measurements, impedance measurements, impedance matching, calibration of directional couplers, VSWR frequency measurements, etc.

To eliminate guesswork, each item of this De Mornay·Budd test equipment is individually tested and, where necessary, calibrated, and each piece is tagged with its electrical characteristics. All test equipment is supplied with inner and outer surfaces gold plated unless otherwise specified.

**NOTE: Write for complete catalog of De Mornay·Budd Standard Components and Standard Bench Test Equipment. Be sure to have a copy in your reference files. Write for it today.**

**The three test set-ups illustrated above include:**

- Tube Mount
- Flap Attenuator
- Frequency Meter
- Calibrated Attenuator
- Tee
- Stub Tuner
- Tunable Dummy Load
- Standing Wave Detector
- Type "N" Standing Wave Detector
- Directional Coupler
- Hight Power Dummy Load
- Cut-Off Attenuator

Stands, etc.

DE MORNAY BUDD

EQUIPMENT FOR 97% OF ALL RADAR SETS

DE MORNAY • BUDD INC., 475 GRAND CONCOURSE, NEW YORK 51, NEW YORK. CABLE ADDRESS "DEMBUD," N. Y.

# NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

**Latest list of preferred tubes; radio conference delegates; d-f services for lost pilots; sunspot predicting service; FCC news**

## FCC Schedules Mobile Radiotelephone Hearing

PROBLEMS invited by rapidly expanding use of radiotelephone for communication with vehicles will be considered at an FCC hearing Sept. 8 at the Commission's offices in Washington, D. C. with respect to the service-allocation of frequencies for the General Mobile Service. Each interested person may appear and participate fully in such hearing provided he files with the Commission, on or before Aug. 15, 1947, a written notice of appearance together with 15 copies of a statement setting forth the names of the witnesses he intends to call at the hearing and a summary of the testimony and exhibits each witness will offer.

Forty channels are now provided in the 30-40 and 42-44 mc bands for Highway Mobile experimentation, including water, land, and air craft. Twenty-four channels are set aside in the 152-162 mc band for Urban Mobile service on the basis of shared use with rural subscriber and short-distance toll telephone service.

As a general rule, highway use covers service between cities and in the open country, while urban service means local use within a radius of 25 miles.

The common carrier type of mobile radiotelephone service is expanding at a rapid rate, with urban service somewhat more in demand than highway service. The rate of expansion is delayed only by the inability of manufacturers to furnish the necessary radio equipment as rapidly as required. Even so, common carrier mobile service has been authorized in 58 cities in the United States, and also in Honolulu. It will be provided, for the most part, by the Bell System and independent telephone companies. The telephone industry has authorizations for about 5,600 mobile units in the urban service. Its projected investment totals about $6,000,000. Thirty-seven licensees have been authorized to charge for this service.

Common carrier highway service is proposed for 79 domestic cities and two in Hawaii. Some 3,200 mobile units have been authorized in this category which, together with land stations, represent an investment of $4,500,000.

In highway system operation, the mobile service operator may have control of more than one land transmitter. When the vehicle is beyond the range of the first transmitter, another transmitter is employed, and so on progressively until the desired vehicle is contacted.

Many economic problems enter into the establishment of mobile systems by independent users. For example, the present commitments of the taxicab industry alone are reported to approach $15,000,000. Adequate systems cost between $6,000 and $10,000. Many small business organizations which could, perhaps, make good use of mobile radio communications have hesitated to go into experimental operation because of the cost and the uncertainty of being permitted to continue at the conclusion of the experimental period.

Representatives of the taxicab, intercity passenger bus, and trucking industries each petitioned the Commission for assurance that their experimental investment would not be lost as a result of future service determinations. The Commission recognizes the need for these services and is making provision for them compatible with the need of other services and the availability of frequencies.

**Status of mobile radiotelephone service installations by the Bell System. More than 30 of the cities shown as having equipment in service (solid dots) in the 30-44 mc band also have urban mobile radiotelephone service in the 152-162 mc band**

## Marine Radar Report

AS A RESULT of the International Meeting on Marine Radio Aids to Navigation (IMMRAN) held April 28 to May 9 in New York City and New London, Conn., delegates of the 31 nations attending issued the following conclusions with respect to radar: High-resolution shipborne radar with ancillary devices having suitable and approved minimum performance capabilities and operated by qualified personnel is a device having wide applicability to

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**Applications are invited from top men to carry on projects under their own direction in modern, fully-equipped plant situated in attractive south-east New Jersey within one hour's ride of New York City.**

**If you can qualify, send us a resume of your education, experience, age and salary requirements. Or, if you prefer, telephone us for an appointment at Matawan 1-1049.**

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RADIO ENGINEERS AND MANUFACTURERS
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*Specialists* in the Development and Manufacture of LF and HF Equipment

maritime use for anticollision, pilotage, above-water obstacle detection, and general position-fixing within range of suitable fixed radar targets either natural or artificial (active and passive). This radar should (a) provide display of a target down to a minimum range of 100 yards, (b) provide display, as two distinct indications, of targets at the same range separated by not more than 3° in azimuth, and (3) provide display as two distinct indications, on the shortest range scale, of targets on the same azimuth separated by 100 yards in range.

A shipborne radar with reduced performance requirements and generally understood to be an anticollision radar against large ships is completely inadequate for the full requirements for position fixing and navigation in coastal and pilotage waters.

A universal performance specification for shipborne radar is an essential prerequisite of the compulsory carrying of equipment by certain classes of ships.

Early action to make the fitting of radar compulsory is not contemplated; this question can be more appropriately examined later.

The administrations of the countries in which these apparatus are manufactured should consider the possibility of issuing specifications serving as a temporary guide for the industry and the purchasers of these apparatus.

A simple and reliable overall performance monitor is essential.

A suitable device should be developed to provide accurate and positive identification by radar of navigational markers, dangers, and shore features. Reflectors should be installed on selected navigational markers in order to facilitate the differentiation of those markers from other echoes, including sea return.

A solution to the problem of in-

(continued on p 244)

## Preferred List of Army-Navy Electron Tubes

| Filament Voltage | Diodes | Diode Triodes | Triodes | Twin Triodes | Pentodes: Remote | Pentodes: Sharp | Converters | Klystrons | Power Output | Tuning Indicators | Rectifiers | Miscellaneous: Cathode Ray | Miscellaneous: Crystals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.4 | 1A3 | | | 3A5 | 1T4 | 1S5<br>1U4 | 1R5 | | 3A4<br>3S4<br>3V4 | | 1Z2<br>1B3GT/8016 | 2AP1A<br>3DP1A<br>3JP1<br>3JP7 | 1N21B<br>1N23B<br>1N25<br>1N26 |
| 5.0 | | | | | | | | | | | 5U4G<br>5Y3GT | 3JP12<br>5CP1A<br>5CP7A | 1N31<br>1N32 |
| 6.3 | 2B22<br>6AL5 | 6AT6<br>6BF6<br>6SQ7*<br>6SR7* | 2C40<br>6C4<br>6F4<br>6J4<br>6N4 | 2C51<br>6AS7G<br>6J6<br>6N7GT<br>6SL7W<br>6SN7W<br>12AU7 | 6BA6<br>6BD6<br>6SG7*<br>6SK7* | 6AC7W<br>6AG5<br>6AG7<br>6AH6<br>6AK5<br>6AN5<br>6AS6<br>6AU6<br>6SH7*<br>6SJ7* | 6BE6<br>6SA7*<br>6SB7Y | 2K22<br>2K26<br>2K29<br>2K41<br>2K45<br>2K48<br>2K50<br>2K54<br>2K55<br>6BL6 | 6AK6<br>6AQ5<br>6B4G<br>6L6GA<br>6V6GT<br>6Y6G | 6E5 | 0Z4A<br>6X4<br>6X5GT<br>1005<br>1013 | 5CP12<br>5FP7A<br>5FP14<br>5JP1<br>7BP7A<br>12DP7A | Photo-tubes<br>1P30<br>1P37<br>1P39<br>1P40<br>927 |
| 25 or over | | | | | | | | | 25L6GT | | 25Z6GT | Voltage Regulators<br>0A2<br>0B2<br>0A3/VR75<br>0C3/VR105<br>0D3/VR150 | |
| Only types for 28 volts anode supply operation | 26C6 | | | | | 26A6 | 26D6 | | 26A7GT | | | | |

* Where direct interchangeability with prototype is assured and its JAN-1A specification has been issued, types with suffix letters GT, Y, W, A, B, etc. may be used.

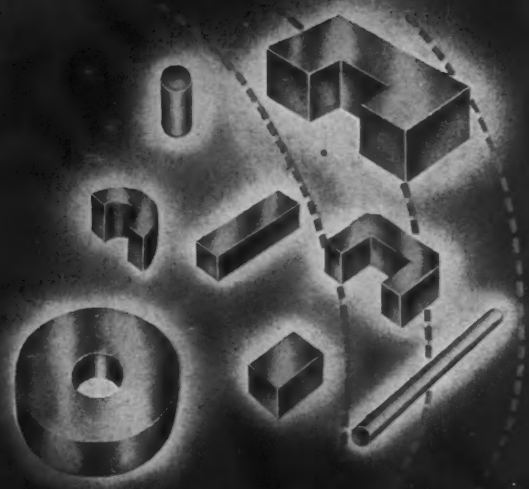
| Triodes | | Tetrodes | Twin Tetrodes | Pentodes | Pulse Modulation | Magnetrons | | Rectifiers: Vacuum | Rectifiers: Gas | Rectifiers: Grid Control | Clipper Tubes | Gas Switching: ATR | Gas Switching: TR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2C39 | 250TH | 4D21 | 8D21 | 2E30 | 3D21A | 2J30–34 | 4J51 | 2X2A | 3B28 | 2D21 | 3B26 | 1B35 | 1B23 |
| 2C43 | 450TH | 5D22 | 829B | | 3C45 | 2J41 | 4J57–59 | 3B24W | 4B26 | C5B | 4B31 | 1B36 | 1B24 |
| 6C22 | 811 | 807 | 832A | | 3E29 | 2J48 | 4J78 | 5R4GY | 6C | 6D4 | 719A | 1B37 | 1B26 |
| 6C24 | 880 | | | | 4C35 | 2J51 | 5J26 | 836 | 16B | 393A | | 1B44 | 1B27 |
| 7C24 | 889RA | | | | 5C22 | 2J58 | 5J29 | 1616 | 857B | 394A | | 1B51 | 1B32 |
| 9C21 | 893A | | | | 6C21 | 2J60 | 5J32 | 8020 | 869B | 884 | | 1B52 | 1B50 |
| 9C22 | 893AR | | | | 715C | 2J61A–62A | 5J33 | | 872A | | | 1B53 | 1B55 |
| 100TH | | | | | | 3J21 | 6J21 | | 1006 | | | 1B56 | 1B58 |
| | | | | | | 4J50 | HK7–T (Series) | | | | | 1B57 | 1B62 |
| | | | | | | | | | | | | | 1B63A |

**Receiving types are listed in upper section, transmitting types below. This preferred list, dated Jan. 28, 1947, supersedes the previous list dated Nov. 1, 1945 and published in the March 1946 ELECTRONICS, p 300. The purpose of the list is to effect an eventual reduction in the variety of tubes used in Service equipment. It is mandatory that all tubes to be used in all future design of new equipments under the jurisdiction of the Army laboratories or the Navy department be chosen from this list. Provisions are made for certain exceptions, however. For permission to use other tubes in Army equipment, write to the Army Laboratory concerned with such equipment; for Navy equipment, write to Electronics Division, Bureau of Ships, Code 930-A, Navy Department, Washington, D. C.**

# STACKPOLE

## SINTERED ALNICO II

***REAL ECONOMY FOR SMALL SIZES AND ODD SHAPES***



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* *Licensed under G-E patents*

**Here is new help on permanent magnet problems—from one of the largest, oldest and most widely experienced producers of molded and sintered components in the industry.**

**Stackpole *Alnico II offers notable economy in the production of units up to two ounces. Odd shapes are a specialty. Engineering recommendations based on your requirements gladly submitted.**

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**BRUSHES and CONTACTS (all carbon, graphite, metal and composition types)—IRON CORES—RARE METAL CONTACTS—RHEOSTAT PLATES AND DISCS—CHEMICAL CARBONS—WELDING AND BRAZING CARBONS—MOLDED PUMP and FLUID DRIVE SEALS—CARBON RHEOSTAT PILES—COIL FORMS, etc., etc.**

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Increase assembly speed up to 50%! Cut down injuries to workers with no burrs, no skids. Reduce production costs. Reduce rejects! Improve product appearance! Go modern with Phillips!

**FOR CLUTCH-HEAD SCREWS**

The latest type recessed-head screw. Screw locks on driver. Can't fall off. No screw-driver slippage. Easy to assemble. Exceptional driver life. Ordinary screw-driver may also be used.

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Scovill is expert in cold-forging unusual special fastenings, such as the one shown. Scovill designing ability, engineering skill, men and machines save money for customers. Consult Scovill!

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**TUBES AT WORK**
(continued from p 134)

as would be the case with appreciable stray coupling.

The noise limiter is the double-action automatic threshold type. Even though the threshold is raised when the beat oscillator is turned on, the limiter is effective on noise encountered during code reception due to its double action type of operation. A control on the front panel is used to adjust the threshold at which limiting action starts. The NC-173 covers the frequency range from 540 to 31,000 kc, plus the range from 48 to 56 mc.

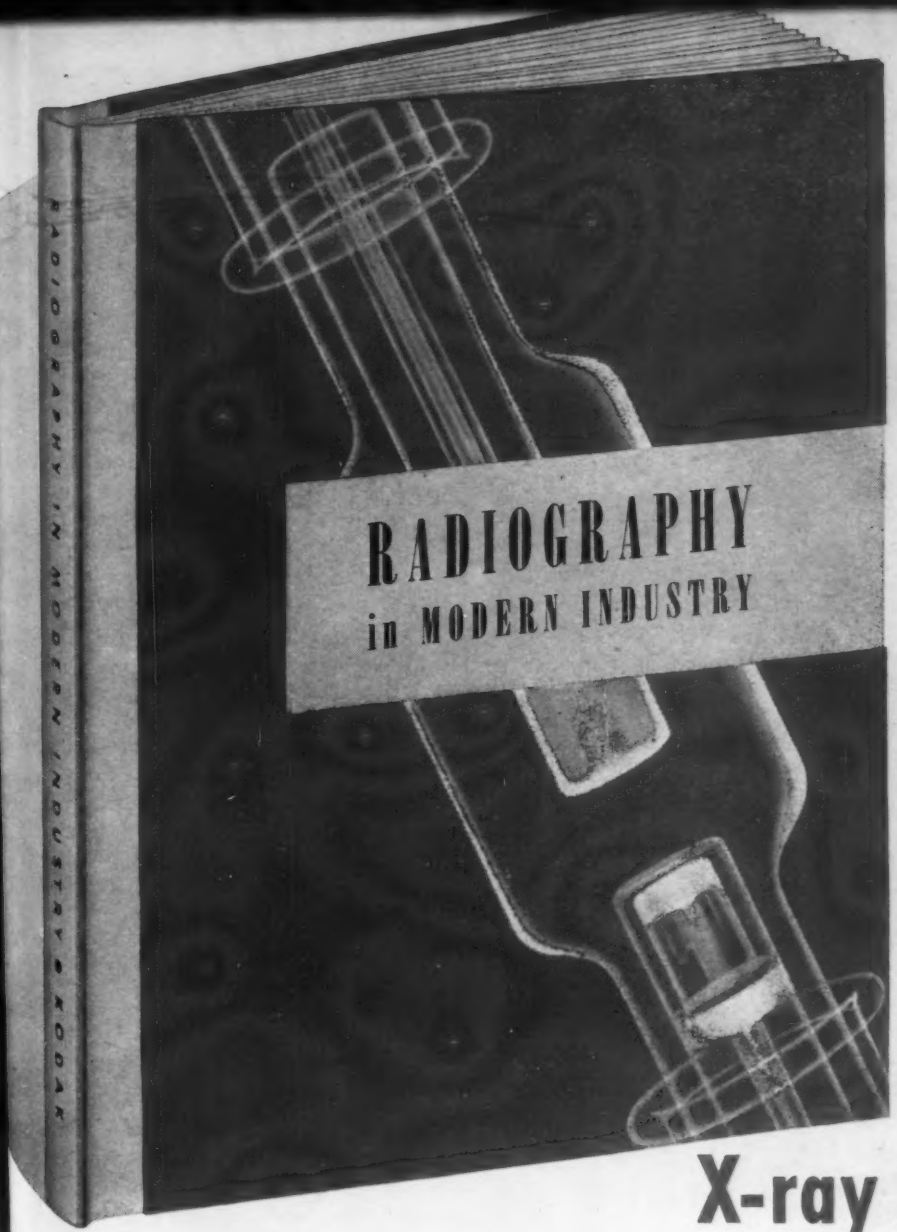
## Electronic Speed-Cop

LATEST "miracle" of electronics to develop from radar techniques is a speed meter that operates on the principle that a radio wave reflected from a moving target will shift wavelength proportional to speed of movement of the target. Microwave energy is radiated from the antenna unit, a portion of the energy striking the surface of the vehicle and being reflected back to the unit. The direct and the reflected signals are received and mixed, and the output signal contains the difference frequency which is directly proportional to the vehicle speed in miles per hour. This speed is read on the linear scale of the meter, calibrated in miles per hour.

The operating zone normally extends about 150 feet in front of the antenna. Speed range of the S-1 model is 0 to 100 miles per hour, accuracy being within 2 miles per hour throughout the range.

A spring-wound graphic recorder

**The electronic speed cop is pointed at advancing or receding traffic to provide direct reading of vehicle speeds**

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2 INSTRUMENTS IN 1

*Shallcross Combined Kelvin-Wheatstone Bridge #638-2*

Save time and money by making *both* low and high resistance measurements with this single portable and highly durable instrument. Ideal for production, field or laboratory work that requires a dependable instrument of a type that doesn't have to be kept under lock and key because of extreme delicacy and high cost.

Used as a Wheatstone Bridge for measurements between 1 ohm and 1 megohm, normal accuracy is better than 0.3%. Low resistance measurements on the Kelvin range utilize current and potential terminals to eliminate lead and contact resistance. Kelvin measurement accuracy is 3% or better, which is satisfactory for most all low resistance measurements. Write for the Shallcross D-C Bridge Bulletin.

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Shallcross Kilovoltmeters, Kilovoltmeter Multipliers and Corona Protected Resistors are available in types for practically all high-voltage test and measurement purposes. Special high-voltage instruments designed to match your needs. Write for Shallcross Bulletin F.

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may be plugged into an auxiliary circuit and will furnish a graphic record of the speed of the moving vehicles. This operates at a speed of 1.5 inches per minute and holds 100 feet of tape.

The instrument has numerous applications in traffic engineering studies and also in the police field.

As designed by engineers at Automatic Signal Division of Eastern Industries, Inc. of Norwalk, Conn., the meter operates either from a 6-volt automobile battery or a 115-volt 50-120 cycle power supply. The current drain from a storage battery is about 8 amperes and the a-c power rating is approximately 50 watts.

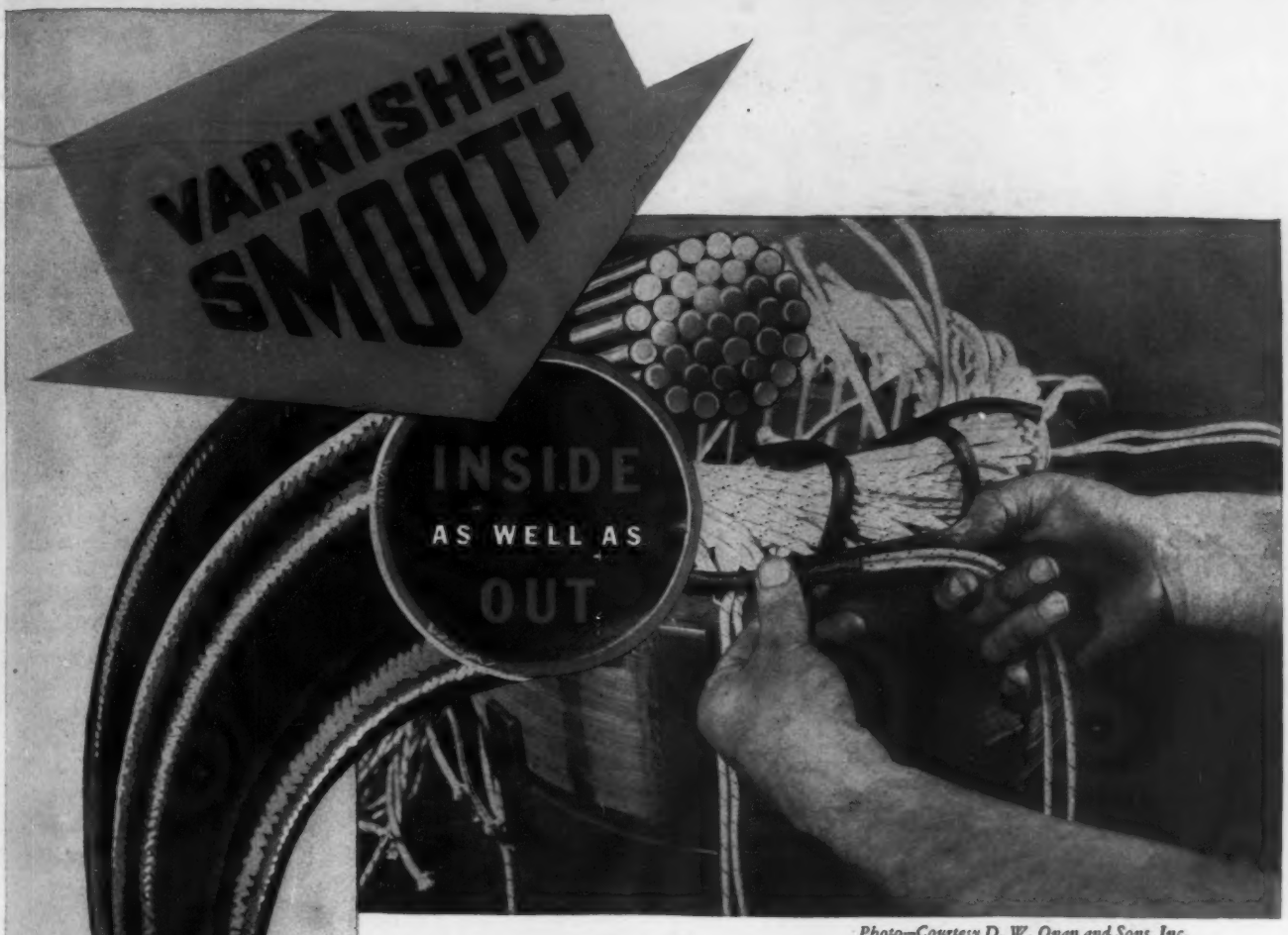
Since the speed meter radiates energy, it is necessary that a station license be obtained from the FCC. An operator's license is not required for an authorized employee to use the meter within the territory of the applicant, but the Commission's regulations require that only the holder of at least a second-class license may adjust or service the equipment.

## Electronic Micrometer Uses R-F Energy

AN ELECTRONIC micrometer used to measure the displacement of a six-inch turbine shaft in its journal is so sensitive that a deflection of 0.01 inch of the center of the shaft provides a two-inch movement of the center spot on a cathode-ray tube. Readings to 0.001 inch are easily obtained and the indication on a meter is linear to within a fraction of one percent.

Developed by M. L. Greenough of the National Bureau of Standards, the instrument was primarily designed to afford a means for measuring thickness of the oil film in the bearings of a large Navy turbine shaft.

The circuit of the unit utilizes the fact that r-f energy radiated from a coil is at zero at the surface of a perfectly conducting shield adjacent to that coil. This phenomenon occurs because the eddy currents set up in the shield by the field of the radiating coil create their own opposing magnetic field at the surface of the shield. The opposing field exactly cancels the




*Photo—Courtesy D. W. Onan and Sons, Inc.*

# IRV-O-VOLT *flexible* VARNISHED TUBING

## SPEEDS ASSEMBLY . . . INCREASES INSULATION PROTECTION

The smooth inside surface of IRV-O-VOLT tubing speeds assembly, even with stranded wire, and cuts production time and cost. In addition, the light inside varnish coating provides a margin of moisture and insulation protection should the outside varnish coating become chafed. IRV-O-VOLT tubing is mechanically strong and flexible; it cuts clean and the cut ends remain smooth and unfrayed. Because of the inside varnish coating, wicking action of the fabric base is eliminated when tubing is used with oil in transformers.

IRV-O-VOLT tubings are fabricated with specially formulated Irvington varnishes skillfully applied to selected, accurately rounded cotton, rayon, or Fiberglas tubular braid. They have high dielectric strength . . . withstand continuously high temperature . . . and are extremely resistant to oil, and moisture. *Because "it's the varnish that insulates" IRV-O-VOLT tubings possess the excellent electrical characteristics and long life common to all Irvington flexible varnished insulations.*

Each grade of IRV-O-VOLT varnished tubing and saturated sleeving meets its respective A.S.T.M. specification and Varnished Tubing Association Standard.

Generous samples of Irvington Varnished Tubings and Sleevings — and also lacquer-coated tubings — will be sent on request.

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If you're designing a Wire Recorder

consider

**Brush Plated Wire**

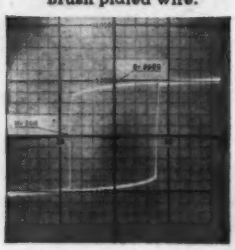
- Constant plating thickness assures uniform signal
- Correct balance of magnetic properties assures good frequency response and high level
- Excellent surface finish assures low noise and minimum wear
- Corrosion resistant
- Easy to handle—ductile —can be knotted

consider

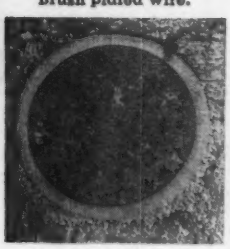
**Brush Wire Recording Heads**

Of principal interest are their excellent electrical characteristics, extreme simplicity of design to avoid trouble, and the "hum-bucking" characteristics, which reduce the effect of extraneous magnetic fields. When required, the head cartridge alone (pole piece and coil unit) may be supplied for incorporation into manufacturers' own head structure.

Hysterysis loop of Brush plated wire.



Cross section of Brush plated wire.



The new Brush wire recording head.

These latest developments in magnetic recording equipment can now be obtained for radio combinations and other uses. Brush engineers are ready to assist you in your particular use of magnetic recording components.

**The Brush Development Co.**

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incident field at the surface of the metal plate.

Moving the pickup coil away from the shield, in the direction of the radiating coil, allows it to pick up a certain amount of energy because the radiated field becomes stronger while the field set up by the currents of the shield becomes weaker due to the change in distance. This condition becomes more marked as the distance between the pickup coil and the shield increases.

The metal background is not a perfect conductor and the coil has measurable thickness so a minimum reading is obtained when the pickup coil is in contact with the metal background. Correction is made by addition of a third coil which permits a zero reading to be obtained.

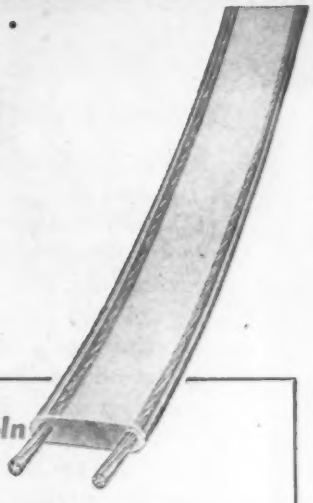
Radio-frequency current is applied to the radiating coil, and when the micrometer is held at some distance from any metallic object, the field from the radiating coil induces voltage in the pickup coil, which is measured either on an oscilloscope or a meter.

For use as a micrometer, the coil assembly is mounted on a movable shaft so that it can approach or recede from a metallic plate. The material to be measured is placed between the pickup coil and the metallic plate and pressed lightly between them. When the material is removed, the amount of current generated in the pickup coil is an indication of the thickness of the material which occupied the space. Calibration of the meter is made

Thickness of a paint spot is measured with the electronic micrometer by its designer M. L. Greenough of the National Bureau of Standards electronic instruments laboratory

CONFUSING? OR AMUSING?

# Lead-In Lines Play an Important Part in Television Reception



The effects of attenuation and impedance mismatch on FM and Television reception are minimized by Anaconda Type ATV* lead-in lines.

The satin-smooth polyethylene insulation of Type ATV line sheds water readily, thus avoiding subsequent impedance discontinuities. This material also has exceptionally high resistance to corrosion. Count on Anaconda to solve your high-frequency transmission problems—with anything from a new-type lead-in line to the latest development in coaxial cables. 47439

*An Anaconda Trade-Mark

**A Type ATV Lead-In for Every Need**

Anaconda offers a complete selection of Type ATV lead-in lines for 75, 125, 150 and 300 ohms impedance unshielded and 150 ohms shielded. For an electrical and physical characteristics bulletin, write to Anaconda Wire and Cable Company, 25 Broadway, New York 4, N. Y.

ANACONDA WIRE AND CABLE COMPANY

# See for yourself how Truarc slashes assembly time, cuts costs

## 2 MINUTES vs. 2 SECONDS!

Right before your eyes is visual proof of how much assembly time can be cut. Each of the many light streaks in the first photo traces another time-taking arm motion, increasing fatigue and reducing efficiency. In the second photo, one Waldes Truarc Retaining Ring replaces six screws and a collar. The assembler uses one tool—a pair of Truarc pliers. The single light streak means one arm-motion. Less time is required for job-training, because Truarc guarantees accurate relationship of parts regardless of the skill of the assembler. Truarc means lighter weight, less bulk. Production and maintenance men find Truarc Rings cut labor and material costs wherever they're used. Their unique taper design assures constant circularity. Their never-failing grip does a better job of holding machine parts together.

There are different Truarc rings for different applications: see what can be done for your product. Send your drawing to Waldes Truarc Technical Service Engineers for individual attention, without obligation.

**WALDES**

**TRUARC**

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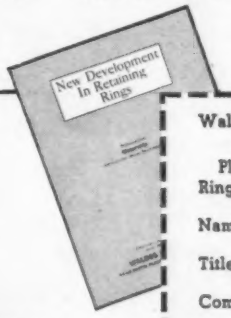
**RETAINING RINGS**

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# THE BALLANTINE ELECTRONIC VOLTMETER, DECADE AMPLIFIER AND MULTIPLIERS

## 10 MICROVOLTS to 10,000 VOLTS

*ONE BILLION TO ONE* — This enormous range of AC voltages — is easily covered by the Model 300 Voltmeter, Model 220 Decade Amplifier and Model 402 Multipliers illustrated above. The accuracy is 2% at any point on the meter scale, over a frequency range of 10 cycles to 150 kilocycles. The Model 300 Voltmeter (AC operated) reads from .001 volt to 100 volts, the Model 220 Amplifier (battery operated) supplies accurately standardized gains of 10x and 100x and the Model 402 Multipliers extend the range of the voltmeter to 1,000 and 10,000 volts full scale.

*Descriptive Bulletin No. 10 Available*

**BALLANTINE LABORATORIES, INC.**

BOONTON, NEW JERSEY, U.S.A.




in thousandths of an inch to give a direct measure of distance or thickness.

To measure the displacement of the turbine shaft in its journal, four of the coil units were spaced equally around the turbine shaft. Each coil unit is about ½ inch in diameter by ¼ inch in length and is able to measure distances from zero to 0.02 inch.

The coil unit can also be employed in a phonograph pickup. Then the vibration of a flat-plate armature fastened to the needle causes a change in the position of this armature with respect to the pickup coil. The modulated output may be rectified and fed into an amplifier for reproduction. In a test of this arrangement, a 455-kc signal was fed into the i-f stages of a conventional superheterodyne and satisfactory operation obtained.

If vibrations adjacent to the pickup coil are created by a metallic diaphragm, and the movement of this diaphragm in turn causes fluctuations in the output of the pickup coil a microphone can be made.

The coil unit may be also used as a thermometer. A strip of bi-metal of convenient length is so mounted that it extends in a path parallel to the end plane of the pickup coil, positioned closely adjacent to that coil. As the bi-metal bar bends in accordance with heat, its free end is brought closer to or farther from the pickup coil and an indication is given on a meter calibrated in degrees.

For use as a tachometer or speed indicator, the end plate of a flyball governor may be so mounted as to approach or recede from the pickup coil as the speed of the rotation of the governor increases or decreases. Many other uses of the unit will probably be found.

## Shunt-Fed Wing Antenna

A NEW system of external antenna wiring for airplanes which will help to eliminate radio static under inclement weather conditions has been announced by Air Material Command engineers at Wright Field.

Present exterior antennas interrupt the sleek contours of airplanes designed for supersonic speeds, increase the drag which cuts down the speed, and present protruding

# Close the Gap- BETWEEN

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*Solenoid High Vacuum Valve*
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INDUSTRIAL high vacuum processes . . . the manufacture of refrigeration units, electronic tube production using trolley exhaust systems and rotary machines . . . demand maximum efficiency. Elimination of manual control with its waste of time and labor can be a large part of the solution.

The new DPI Solenoid High Vacuum Valves provide instant finger-tip control over high vacuum systems. They constitute a positive advance toward fully automatic control of high vacuum production. What savings they can deliver in time and effort, and how far they can "close the gap," can be determined only after individual study.

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**For further information on Solenoid High Vacuum Valves write —**

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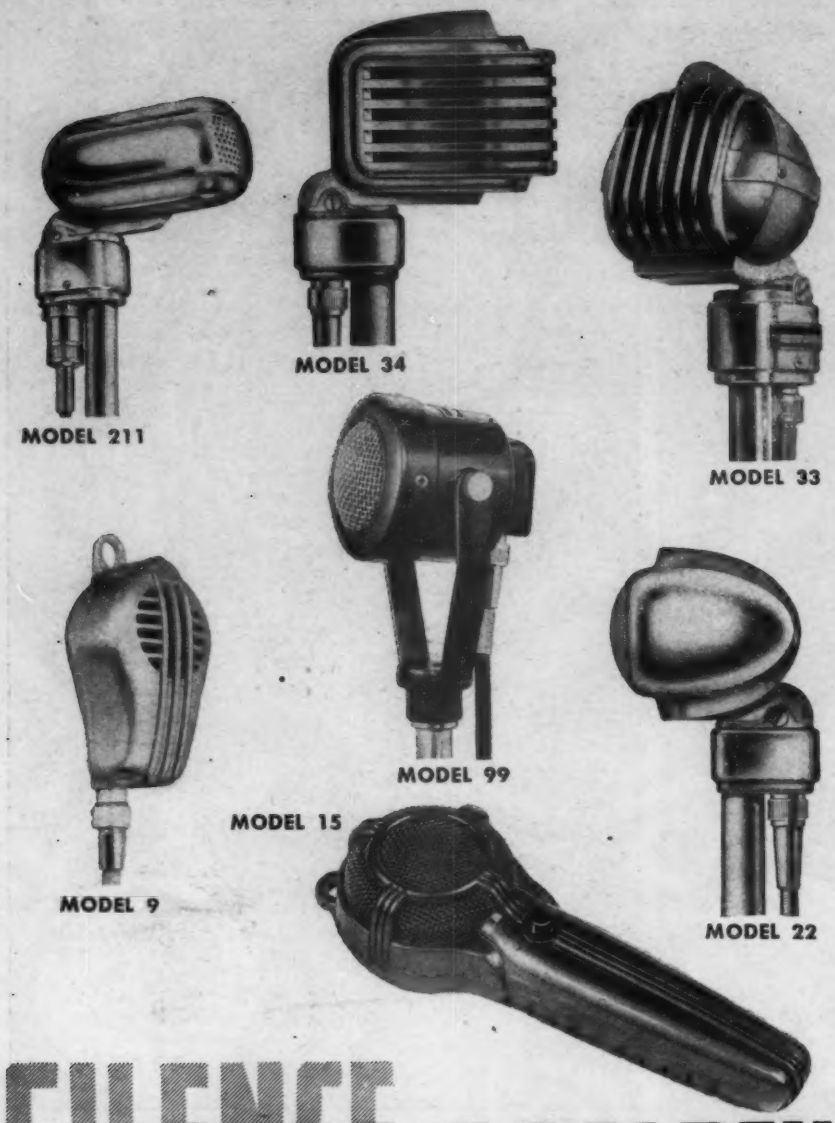


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surfaces which tend to pick up ice in icing conditions. Because of this it has become necessary to devise new types of radio antennas.

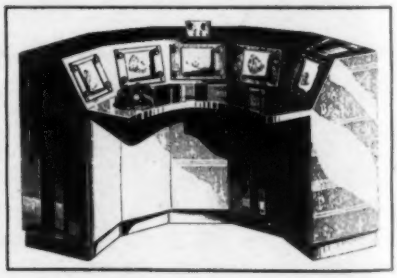
Exciter coils are installed between the inboard engines and fuselage that energize the entire wing structure so that the wing itself acts as an antenna. Operation is superior to the standard wire antenna that stretches from vertical stabilizer to cowl or the trailing wire antenna. These two standard types of antennas prevent drag, icing, and oscillation problems. Icing and oscillation of the unstabilized wire antennas bring about a frying-egg sound in receivers.

Another experimental antenna installation recently made by Wright Field engineers is a flush-mounted slit antenna at the side gunner's position of a B-17, which would be adaptable to most types of aircraft. This installation is intended for use with homing devices installed in aircraft.

## Shore-Based Radar for Port of Liverpool

PRECISION 3-cm radar with a sector-scanning antenna having a bearing discrimination of better than 1 degree is now being constructed by Sperry Gyroscope Co. Ltd. of England for installation at Gladstone Dock in Liverpool. Operation is scheduled to begin in the spring of 1948. The equipment will serve for harbor supervision, showing the exact positions at any instant of all ships in the channel approaches and their relationship to all buoys in the Liverpool Bay area under all weather conditions.

The control console will have five cathode-ray displays arranged in



Control console of Liverpool harbor radar. The presentations on the five cathode-ray tubes will permit talking ships up and down the winding approach channel by radiotelephone in the thickest fogs

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MX Rim Drive Constant Speed Electric Phonograph Motor
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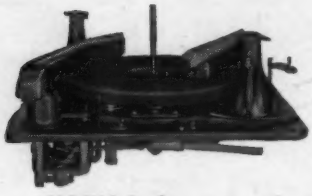

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GI-R90 Dual Speed, Home Recording and Phonograph Assembly

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1. AMPLE POWER AT CONSTANT SPEED . . . eliminates instantaneous speed variations.
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logical relation to each other. The first will show the entire scanning sector for the 20-mile range of the equipment, and the next four will each show in enlarged form a precision picture in the limited arc and range corresponding to the portion of the Channel being monitored. Buoys and other fixed navigational marks will be plainly indicated on a chart in front of each tube so that identification of echoes from these objects is rapid and unmistakable. Rectangular grid lines over each display enable the grid reference of a new echo to be read directly for locating the position of any vessel on a chart having corresponding grid lines. Such data can be communicated directly to any vessel by radio, for navigational guidance during poor visibility. Drifting buoys can be detected quickly on the radar screens, eliminating the need for routine checks by a tender and staff.

The antenna scanner unit will be mounted on the roof of a cabin atop an 80-foot steel tower, with the remainder of the equipment in a building at the foot of the tower. Provisions are made for addition of remote displays later.

This harbor radar installation is expected to be of most value during thick weather that would otherwise neutralize the port facilities. By using radiotelephone and radar together to talk ships into and out of the port during fog, much as planes are brought down through fog by GCA, ship turn-around time can be made more nearly independent of visibility conditions. To the shipowner this can often mean the difference between the financial success or failure of a voyage.

## British Metal-Spray Circuits

By F. R. Brewster
*McGraw-Hill World News*
*London, England*

A METHOD of spraying metal for electrical circuits of radio and television receivers has been successfully developed by a new British firm headed by the inventor, John A. Sargrove. The method involves metal-spraying both faces of a flat plastic base molded with recesses and webs so shaped that the filler metal performs the functions of

# HOW JOHN DEERE SOLVED THE PROBLEM OF THE ANONYMOUS DEALER...

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Most consumers buy durable goods from dealers . . . not manufacturers. When the need for service, parts or re-purchase occurs, it isn't the distant factory but the dealer who gets the call.

Manufacturers can provide pool-purchased standard, personalized dealer Decal nameplates to their outlets at a saving of 80% over former prices . . . and at no cost to themselves.

*International Harvester, Oliver and J. I. Case solve the problem of the "anonymous dealer" with pool-purchased standardized dealer Decal nameplates, too!*

Today . . . combination "factory-dealer" Decal nameplates link John Deere's trademark with their dealer's name, address and phone number on the equipment they sell. Formerly a few scattered dealers bought their own Decal nameplates. Relatively high cost of small individual dealer purchases limited the practice to only the largest. There was no uniformity of design. Nameplates varied with each dealer. Few included the manufacturers' name.

Pooled factory buying, stimulated by direct mail to dealers, now enables John Deere to sell a standard, personalized Meyercord Decal dealer nameplate to their outlets at a fifth of the former cost. It costs the factory nothing—saves the dealer 80%.

Whether you make farm equipment, stokers, lawnmowers, electric appliances or what—the problem's the same. Of course your product is factory identified—but what about the dealer? Is he *anonymous?* Assure ease and speed of dealer contact for your ultimate consumer with a standard, personalized factory-controlled Meyercord Decal dealer nameplate program for *your product.* Meyercord Decals are durable, easily applied and can be produced in any colors, size or design. Send for complete "dealer identification" details. Address Dept. 9-7.

NOTE: *The big, colorful, weather-resistant Decal trademarks you see on leading makes of farm equipment today are made by Meyercord.*

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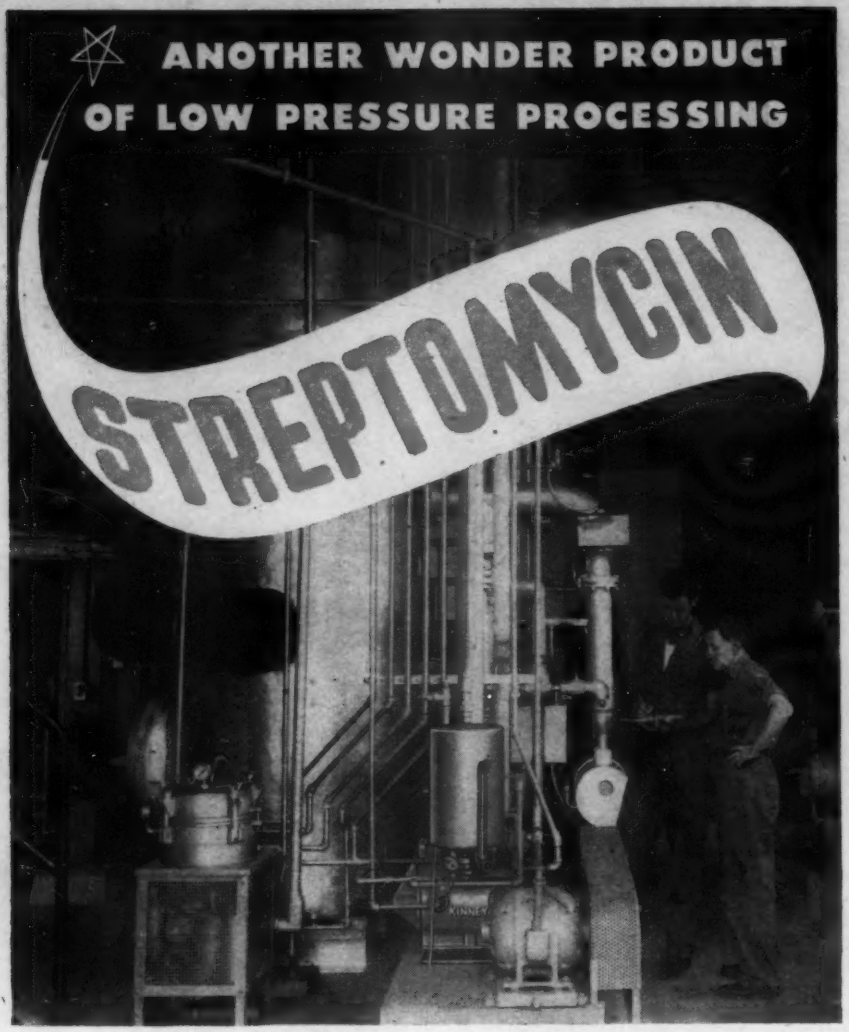
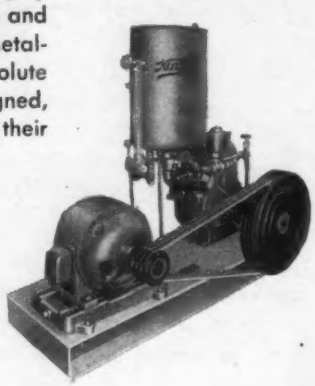



Kinney High Vacuum Pumps play an important part in the freeze-dry process at the new Streptomycin Plant of Merck & Co., Inc. at Rahway, N. J. Under super sterile conditions, vapor from the sublimation dryer is frozen in a high vacuum at —80 deg. C. in the condenser and removed as snow. Kinney Vacuum Pumps are giving highly dependable service in the production of this and many other pharmaceutical, food, optical, metallurgical and other products where low absolute pressures must be maintained. Compactly designed, Kinney Vacuum Pumps save floor space, and their fast pump down and low ultimate pressures shorten production time and reduce costs. Kinney Single Stage Vacuum Pumps produce low absolute pressures to 10 microns; Compound Pumps to 0.5 micron.



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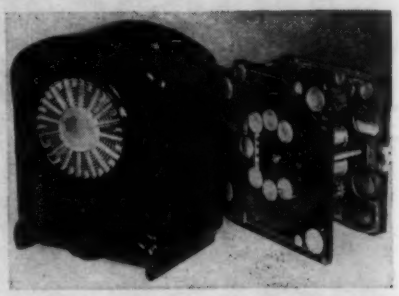


**Two tube medium-wave receiver made by spraying metal into recesses in a plastic base**

wires, resistors, inductances, and capacitor plates.

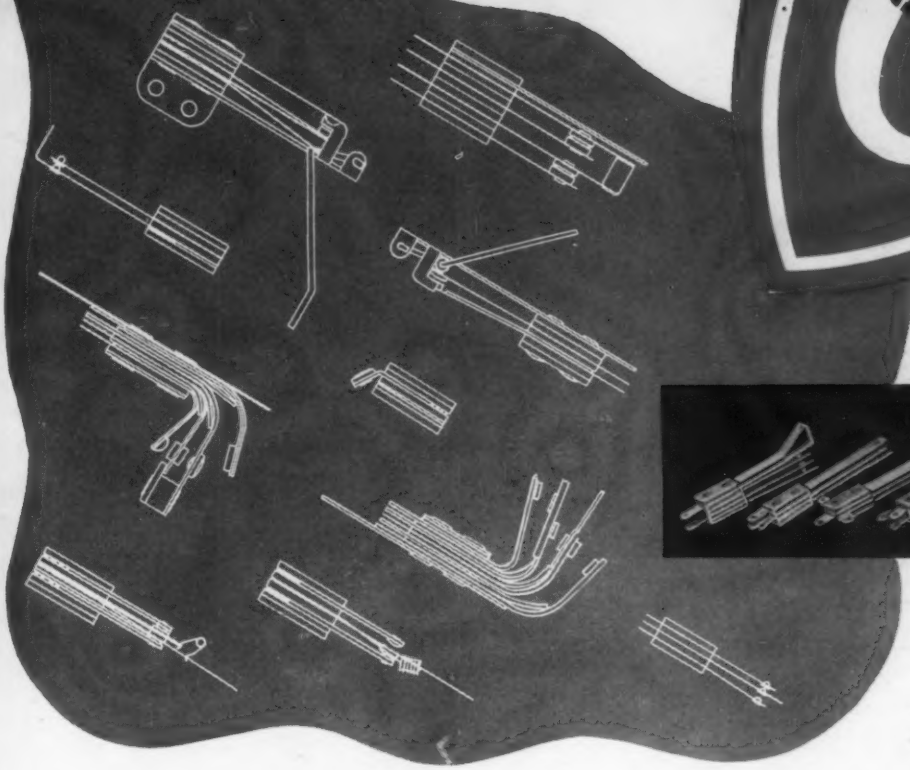
At present the method is being applied to the manufacture of radio receivers, all the electronic circuits of which are turned out complete as a single unit, requiring only the insertion of tubes and electrolytic capacitors in their appropriate holders, mounting the loudspeaker, and assembling the chassis in the cabinet. The process could be used equally well to produce separate elements for each main part of the circuit such as r-f, i-f, and output stages, these units then being mounted together one above the other on metal rods. By suitable design of the circuits and by metalizing the holes through which the rods pass, connection between the units is obtained. At present, however, only fairly simple circuits for medium-wave receivers are being made.

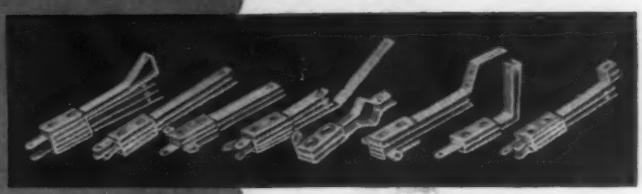
The production method is completely automatic and continuous in flow. The plastic base pieces are fed into the apparatus at one end and a completed element is turned out at the other end every twenty seconds, after spraying, milling, lacquering, and testing. Sectionalized conveyors are employed and each phase of the production process is separated from the next by an air-lock. Each stage of the operation is electronically controlled and if any one process fails or lags, all other stages up to that point are stopped.

## Radar Signals Guide Missiles in Flight

MODIFIED from fire-control radar, a new technique is now being used to control guided missiles and pilotless airplanes in flights to target areas. A B-17 was used as a missile

# Switches FOR DESIGNS OF TOMORROW OF TODAY





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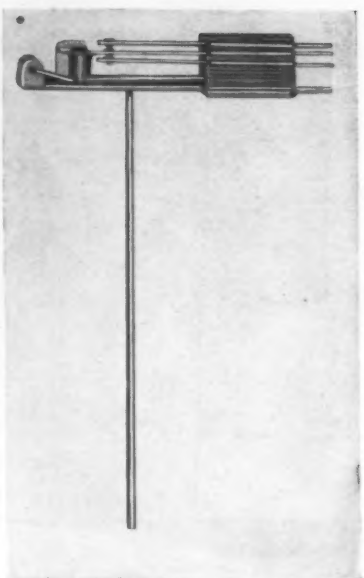
**Scan the brief pictorial review of Guardian Contact Switch assemblies shown above and you will probably see a switch that is comparable to your needs. Each unit represents a switch so practical, so saving of assembly time, energy, materials and money, as to be worthy of your immediate consideration.**

**The Guardian Featherub Switch is an example of such true efficiency. It is shown to the lower right of this page. An original Guardian creation, it is actuated mechanically and is adaptable to manual, roll-over or cam action. The Guardian Featherub and all other units shown are standard items. There are hundreds of other types, all of the highest quality. Contact blades are obtainable in phosphor bronze tinned to withstand salt spray test, also in standard Guardian phosphor bronze. All switches are properly insulated. The switch you need is here singly or in combination . . . one or a million! Try Guardian Switches for performance, price and delivery.**

*Your cost-free copy of Guardian's new Catalog 10-A is waiting for you. Write on your business letterhead for it today:*



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during a recent demonstration for high-ranking Army officers by engineers of the Air Materiel Command's electronic division who successfully controlled the 60-mile flight of the aircraft from a position over Wright Field to a point over a selected target.

Although the plane was invisible to the controlling engineers and inspecting officers, the course of the aircraft was automatically plotted as a red trace on a map table coupled to the ground radar. The radar tracked the aircraft throughout its flight.

Two switches on the plotting table are used to pilot the plane. These switches vary the ground radar pulse signals. Manipulation of the switches determines whether the plane turns right or left, loses or gains altitude. Variations in the pulse signals trigger a small receiving set in the aircraft and this in turn, controls the operation of the plane's automatic pilot.

Engineers at Wright Field are now at work on designs of new systems capable of guiding several missiles simultaneously and controlling them at extreme altitudes and extended ranges.

## Radar Beacon for Lighthouse Keepers

A SMALL RADAR beacon for lighthouses, emitting signals which will be detected by radar-equipped ships, has been built by General Electric for the United States Coast Guard. It was tested at special demonstrations of merchant marine navigational aids in May at New London, Conn.

The unit should prove useful during periods of fog, rain, snow and sleet when normal sight and sound warnings are limited.

Signals from the electronic beacon will appear as a bright ray on the radar's indicator showing the exact direction of the beacon, in the same way that the conventional lighthouse is located by the beam of light it emits.

Use of such radar beacons would also aid radar navigation, especially on coast lines where the surfaces are flat and give a poor radar reflection on the screen of existing

Kovar meets exacting requirements for sealing to glass. Here are a few outstanding features:

1. For use with hard glass, having high thermal shock properties and permits high temperature evacuation.
2. Matches expansivity of the glass over entire temperature range (up to the plastic state of the glass) resulting in strain-free seals.
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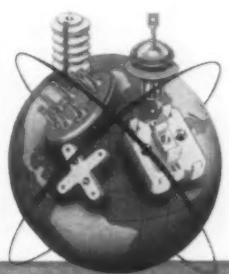
6. Mechanical strength—full metal thickness without "feather edge."

Kovar has gained world-wide acceptance and is used by leading American and foreign manufacturers. It is easily machined or cold formed and is available in all desired shapes—sheet, strip, foil, wire, rod, leads, tubing, cups, eyelets and flanges.

When writing for literature, please state the nature of your proposed application.

*Write for Literature*



*Trade Mark No. 337962
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| Radio Broadcast Equipment | K-12, K-13, K-14 |
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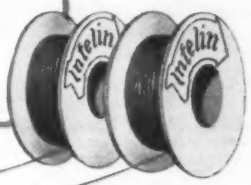
**DATA FOR K-45 AND K-51 CABLES**

| Nominal Attenuation (db/100ft) | K-45 | K-51 |
|---|---|---|
| at 30 Mc | ..... | 1.7 |
| 100 Mc | 2.0 | 3.6 |
| 300 Mc | 4.0 | 7.0 |
| 400 Mc | 5.3 | 10 |
| 1000 Mc | 8.5 | ..... |
| 3000 Mc | 17 | ..... |
| Characteristic Impedance—Ohms | 52 | 95 |
| Capacitance per Foot (uuF) | 29 | 16 |
| Volts (rms) | 15000 | 5000 |

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1910 N. Front Street, Philadelphia 22, Pa.

**Designed for Coast Guard by G-E engineers, this microwave beacon acts as a lighthouse for radar-equipped ships**

equipment. Several units in lighthouses on the coast would also give the navigator a triangular fix and act as an accurate position-indicator.

The transmitter, oddly enough, uses a lighthouse tube operating at 3,200 megacycles. This feeds into an omnidirectional vertical dipole antenna that resembles a policeman's nightstick in appearance. The lightweight transmitter and antenna are shown in the accompanying photograph.

## Aural Current Indicator

By T. A. Benham
*Haverford College*
*Haverford, Pa.*

The author, inconvenienced through lack of sight, has designed a meter which will enable a blind person to read accurately currents in a circuit where the current is static or varies only slowly. This is accomplished by clamping the pointer of a more or less conventional instrument so that the pointer will not move while being felt. This is, however, too clumsy when it is required to tune a circuit for a maximum or minimum current or voltage condition since it requires the taking of a great number of readings, clamping and releasing the pointer each time.

Suppose a saturable reactor hav-

# Studying the output of pulsed oscillators?

# ANALYZE THEIR SPECTRA VISUALLY WITH THIS COMPACT INSTRUMENT!

## THE SYLVANIA SPECTRUM ANALYSER

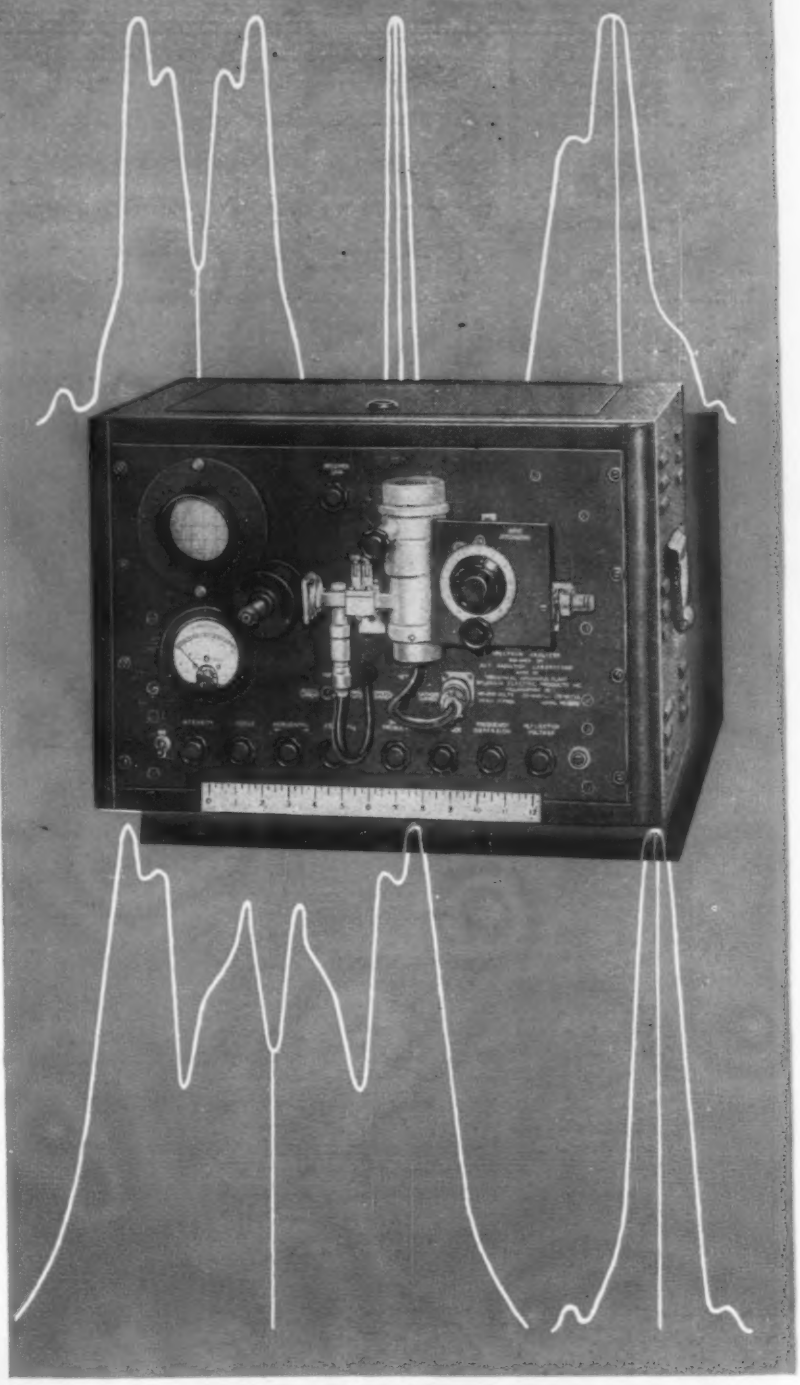
provides a convenient means of studying the energy spectrum of microwave generators operating as pulsed oscillators or modulated CW oscillators. The output of magnetron, klystron, rocket and similar UHF and SHF tubes can be readily investigated.

Essentially, the Sylvania Spectrum Analyzer consists of a sharply tuned superheterodyne receiver with a cathode ray oscilloscope indicator. The instrument incorporates a sawtooth generator, which performs the two functions of frequency-modulating the local oscillator and of providing the horizontal sweep for the oscilloscope. Thus automatic synchronization is assured at all times.

An input probe is provided for insertion into cavities or wave-guides.

The energy emitted by the oscillator at various frequencies is displayed on the cathode ray tube as a pattern of vertical lines. The envelope of the pattern represents the spectral distribution.

The Spectrum Analyzer illustrated—the TSX-4SE—is designed for the 9,300 Mc region. A second model—the TSS-4SE—is available for the 3,000 Mc region, and a third model—the TSK-2SE—is available for the 24,000 Mc region.



## TYPICAL APPLICATIONS OF THE SPECTRUM ANALYZER

Some of the possible uses include:

Viewing the output of a radar system, to make sure that the output energy is not being wasted by being distributed over a wider frequency band than the radar receiver can accommodate.

Determining the frequency of a pulsed oscillator.

Adjusting the local oscillator frequency of a radar receiver to space it properly with respect to transmitter frequency.

Checking of pulling or shifting in frequency of the pulsed oscillator of a radar transmitter, by observing the spectrum while the antenna is in motion.

Measurement of standing wave ratios by using the Spectrum Analyzer in conjunction with a slotted section.

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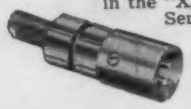

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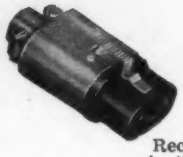
X-3-11 Plug in the "X" Series

XK-3-12 Plug in the "XK" Series



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TQ-1-12 Plug in the "TQ" Coaxial Series

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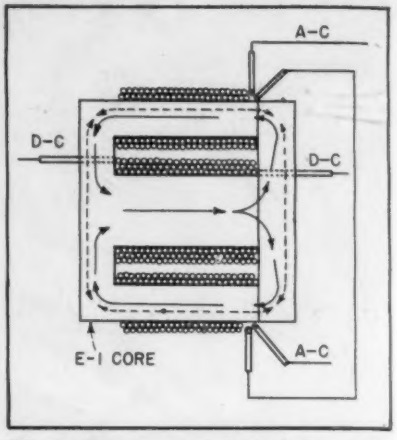


**FIG. 1—Arrangement of windings on the core of the reactor. The solid arrows indicate d-c flux lines, dashed arrows the a-c flux lines**

ing two coils wound on the outside legs of an E-I lamination were connected in series and used as part of the oscillating circuit in a vacuum-tube oscillator operating on a frequency of 200 cycles. Then, suppose a winding were placed on the center leg of the E as shown in Fig. 1.

The frequency of oscillation will depend on the inductance of the outside coils as determined by the number of turns on the coils and the permeability of the core material. The permeability is varied by causing the current to be detected to pass through the center winding. The greater this current, the lower the permeability; the lower the inductance, the higher the frequency of oscillation.

An oscillator was built, as in Fig. 2, and it was found that a

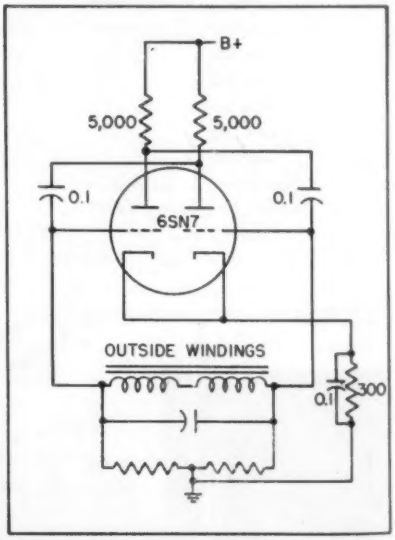


**FIG. 2—Circuit of 200-cycle oscillator whose frequency increases with an increase of direct current through one winding of the saturable reactor shown in Fig. 1**

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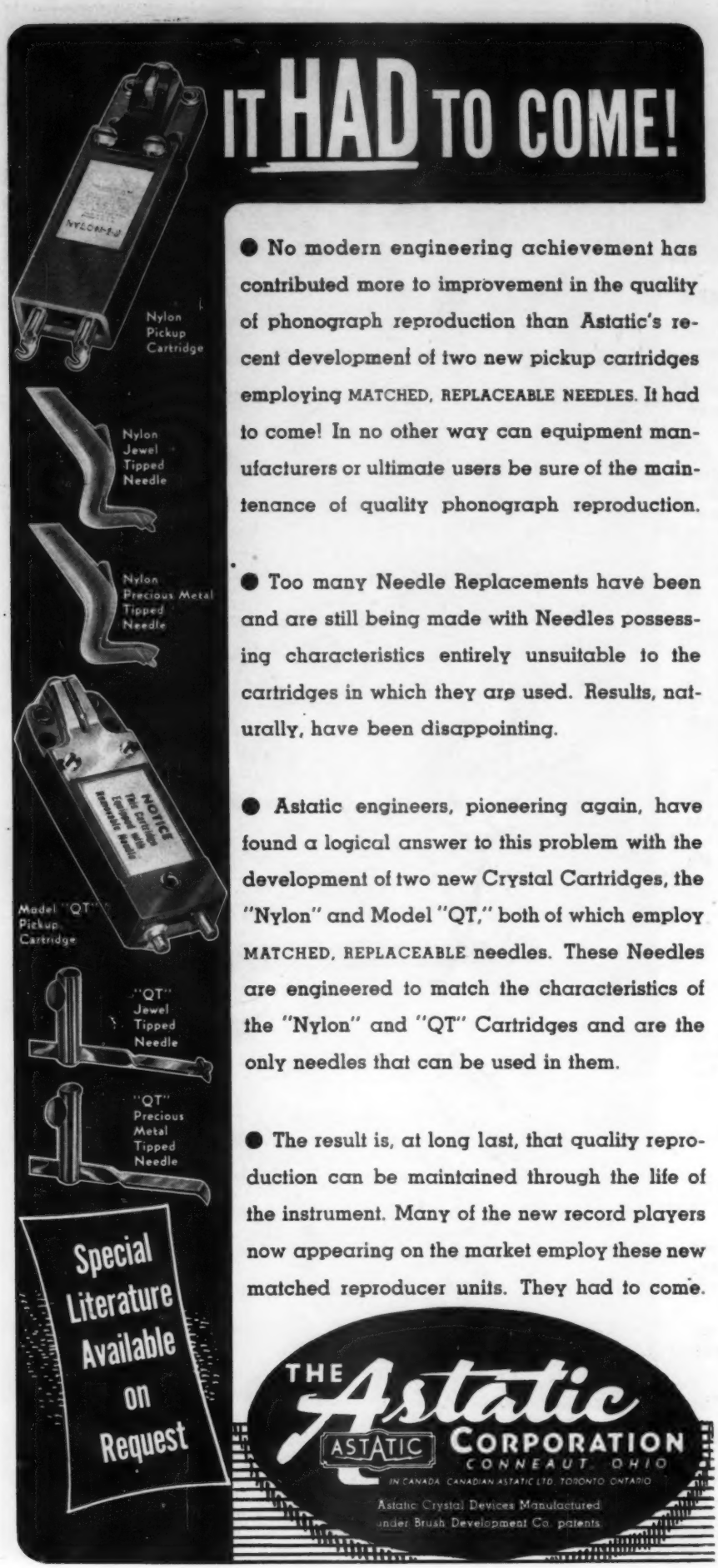
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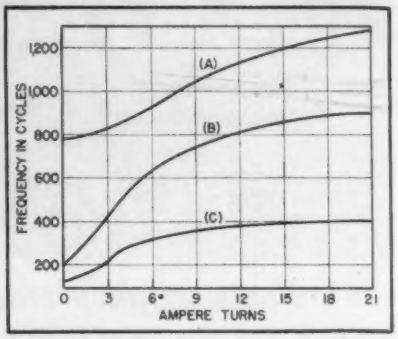


**FIG. 3—Curve A applies to a silicon-steel core and a 0.1-μf capacitor; curve B, mu-metal core and 0.02-μf capacitor; curve C, mu-metal and 0.1 μf**

change of from 0 to 1 ma changed the frequency from 200 to 270 cycles and that 10 ma raised the frequency to 770 cycles.

A silicon-steel core of the same type was tried, but the small currents did not produce usable changes in frequency. Figure 3 shows frequency plotted against ampere turns for the center coil of the two cores. The mu-metal core has two tuning values because with the original 0.1 μf, the zero-current frequency was 120 cycles which is too low for convenient aural response.

The specifications are as follows:

Mu-metal core, E-I 28, outside coils 1,100 turns each; inside coil, 3,060 turns, 130 ohms resistance; inductance of outside coils together, 19.0 h with 2 volts across; maximum $\Delta F/\Delta I = 265$ cycles per milliampere.

Silicon steel core, E-I 28, outside coils 375 turns each; inside coil 2,500 turns, 125 ohms resistance; inductance of outside coils, 0.316 h with 2 volts across; maximum $\Delta F/\Delta I = 100$ cycles per milliampere.

*Improved Reactor*

The circuit of the final unit is shown in Fig. 4. Using the best of the reactor conditions shown in Fig. 3 required a current of 6 ma to obtain the maximum useful frequency change. In practice, much smaller currents would be encountered, so another reactor was designed and constructed having 7,500 turns on the d-c winding, but with the same a-c coils. Even more turns would be desirable, but high resistance and fine wire were thought unsatisfactory since too high a voltage drop and danger of break-

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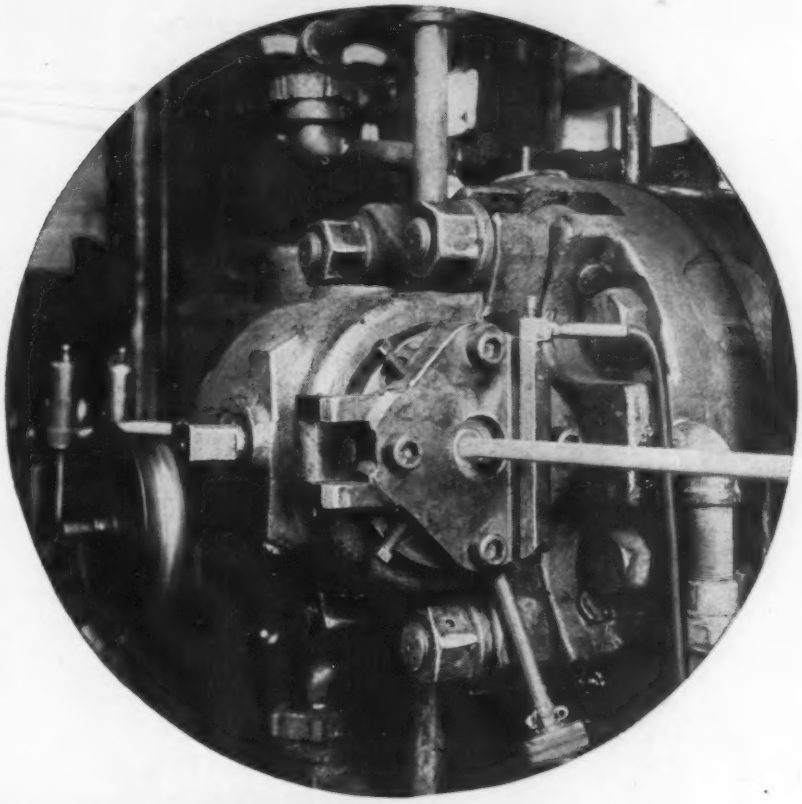

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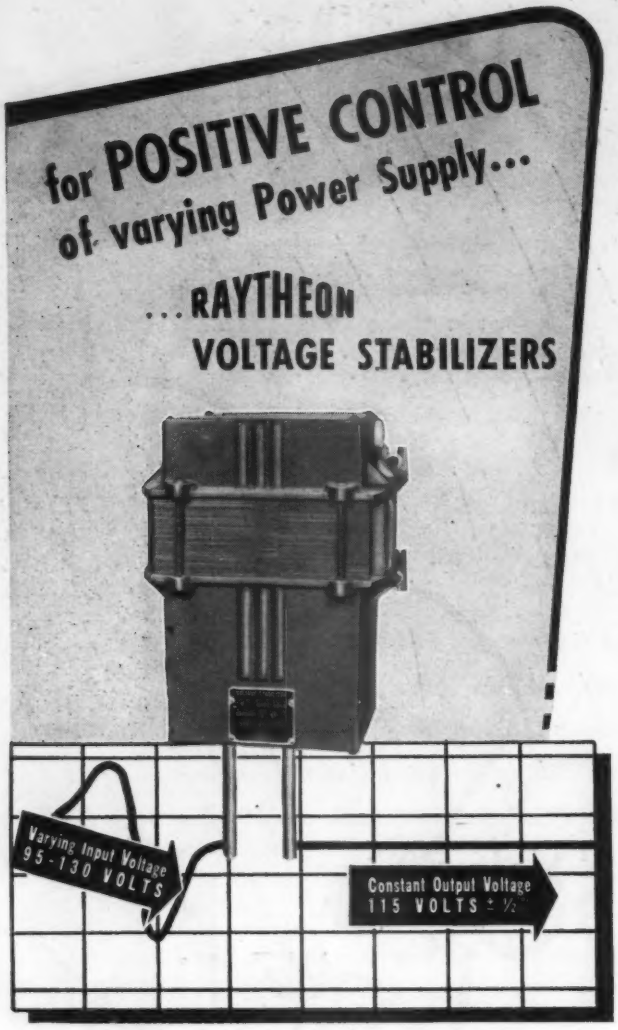


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age would result. This design was then a compromise between maximum possible sensitivity and circuit inefficiency. The curve for frequency versus ampere turns is shown in Fig. 5. Ten ampere turns corresponds to 0.75 ma. This is sensitive to changes of less than 0.1 ma especially at low currents.

Although it is possible to shunt the d-c winding to increase the range of the instrument, this results in two undesirable characteristics. First, the change in current that is detectable is proportional to the total current. That is, if the total current is ten times that flowing through the winding, the minimum noticeable change will be 1.0 ma instead of 0.1 ma. Second, the shunting resistance increases the time required for the change to be noticed. The larger the shunt (the lower the resistance), the more slowly the frequency changes.

To overcome the first of these two effects, a second d-c winding of 100 turns was placed on the center leg. If a current is sent through this winding from d-c source in such a way as to neutralize nearly all the flux due to the current to be studied, then smaller shunts can be used, thus making the change appear to be larger. This smaller shunt also speeds up the time of response.

It would be desirable to have

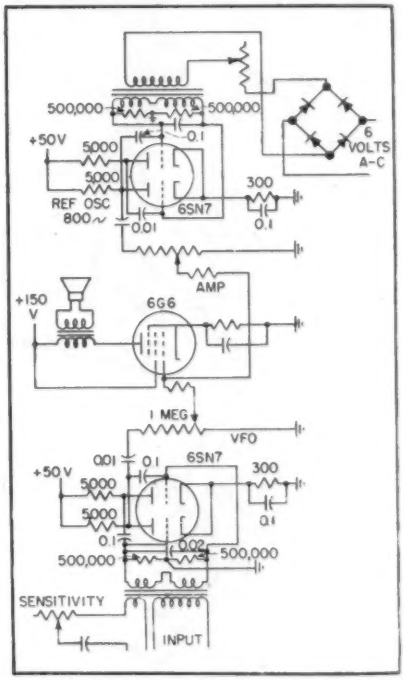


**FIG. 4—Complete circuit of final instrument for aural indication of current changes**

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some means of extending the sensitivity without the necessity of having a larger number of turns on the d-c winding than seems practical or without the need of using amplifiers. This was accomplished by constructing a second oscillator similar to the first except that the d-c winding is excited from a dry rectifier built in the cabinet. The saturating current is controlled by a variable resistor. This permits the operator to adjust the frequency of the second oscillator to give beats with the first.

*Use of Beats*

If the beats are set to two or three per second, for example, then when the small current change through the d-c winding of the detecting circuit takes place, causing the frequency to change only a few cycles, the beats will change. Even though the few cycles difference in the original frequency may not be discernible, the large change in the beat frequency will be easily noticed. Since the comparison oscillator need not be particularly sensitive, ordinary silicon-steel core material can be used.

The meter in which the pointer can be clamped enables a visually handicapped person to read the absolute value of a current. This meter, when used in conjunction with the current-change indicator described, enables him to make adjustments for maximum or minimum currents and then to determine the magnitude of the current.

This combination of instruments, together with several others developed during the past six years, has made it possible for the blind to perform many more operations involving electrical measurements and adjustments than heretofore.

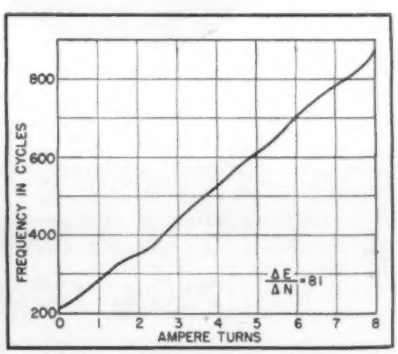


**FIG. 5—Frequency plotted against ampere turns for the final circuit**

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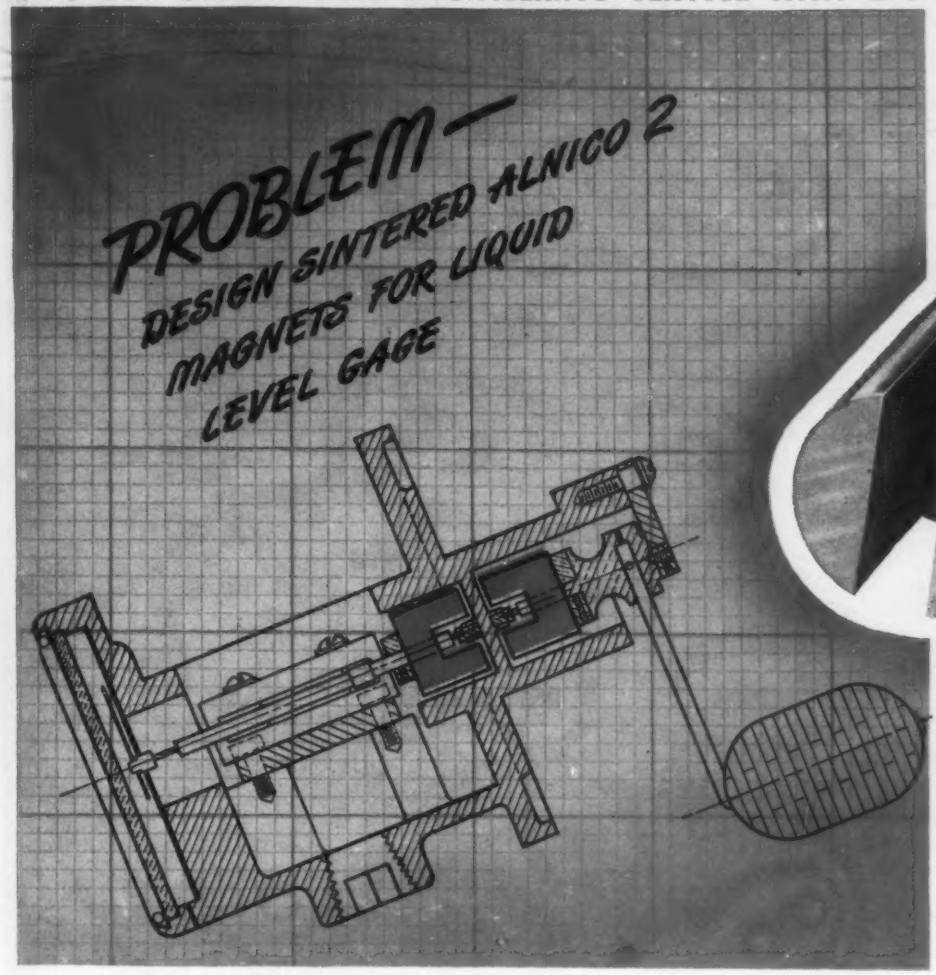


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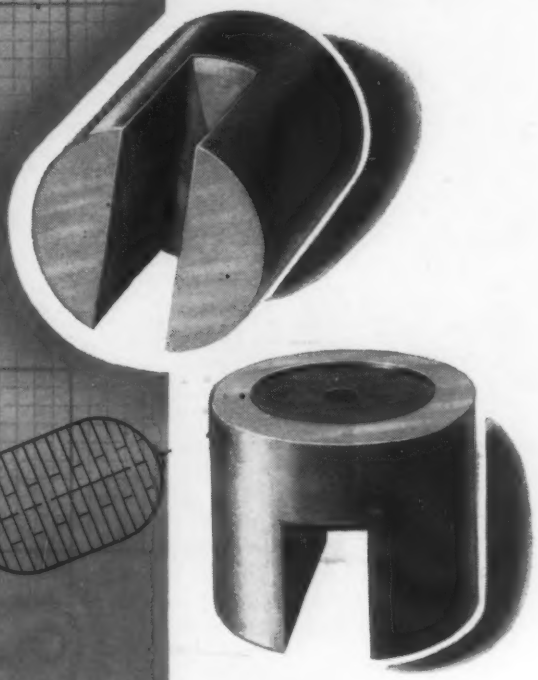

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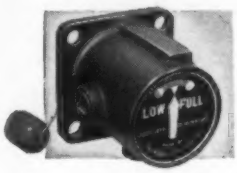


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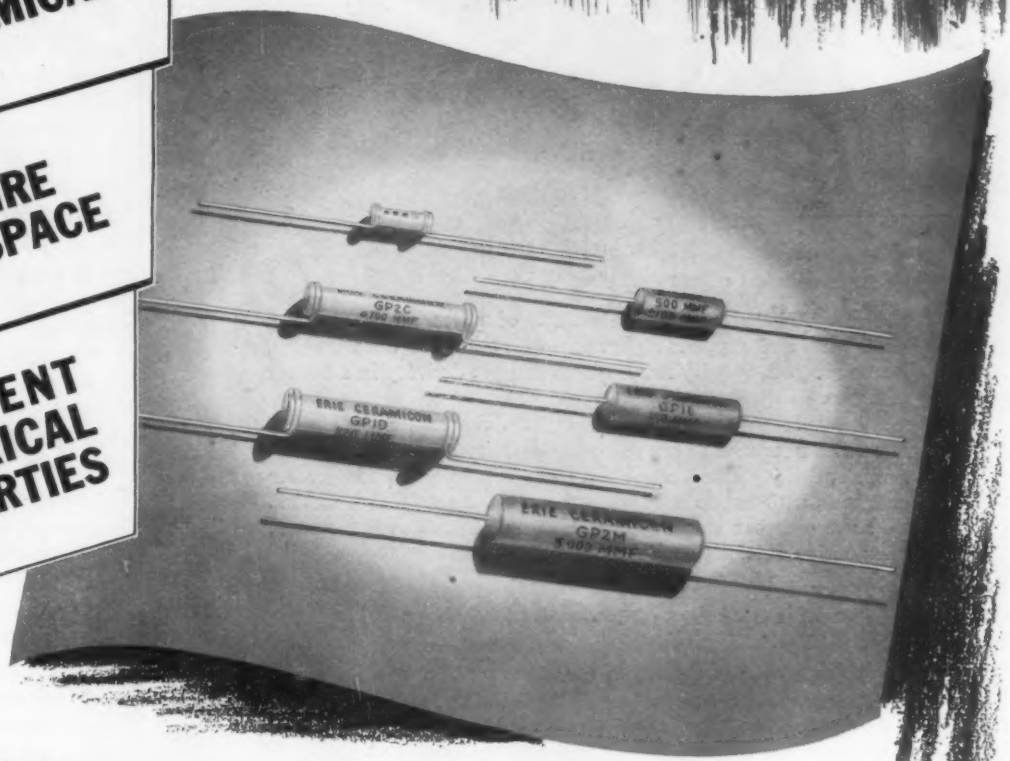


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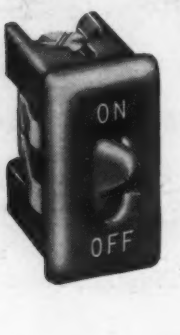

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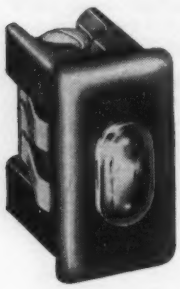

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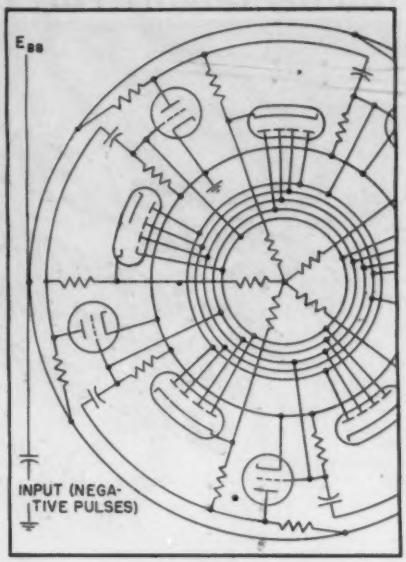


**FIG. 3—A scale of five circuit is built using both triodes and diodes**

causing conduction in the diodes that, in turn, cuts off all the other triodes. Choice of resistances, bias voltages, and other circuit parameters is very similar to that for the scale of two Eccles-Jordan circuit.

Another method of interconnecting $N$ tubes to form such a counter is shown in Fig. 4, drawn for $N$ equal 5. The five tubes are interconnected in such a way that conduction in any one tube cuts off conduction in the two opposite ones. The circuit has five states of stable equilibrium corresponding to the condition that two adjacent tubes conduct and the remaining three do not. A circuit of this type has the advantage of requiring relatively few interconnections between tubes.

### *Triggering*

To switch the circuit successively through its several stable states, triggering pulses are used. Coupling capacitors between plates and grids of succeeding tubes in the circuits of Fig. 2 and 3 carry these pulses. In Fig. 3, a negative triggering pulse is applied to the plate supply as shown. This pulse passes through the plate-grid coupling capacitors driving all the grids negative. However, the conducting tube amplifies and inverts this negative pulse driving the grid of the next tube positive. Conduction is thus transferred around the ring from tube to tube in order. Switching in the circuit of Fig. 2 takes place in similar manner, resistors $R_2$ be-

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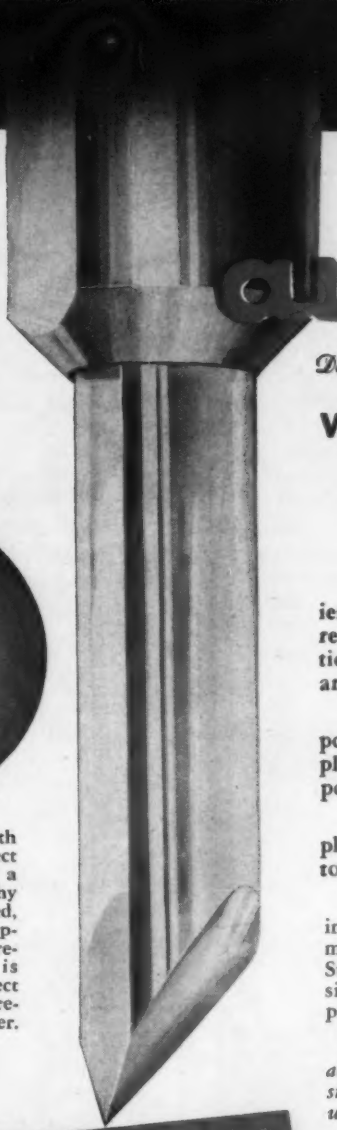

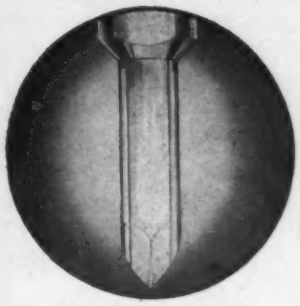

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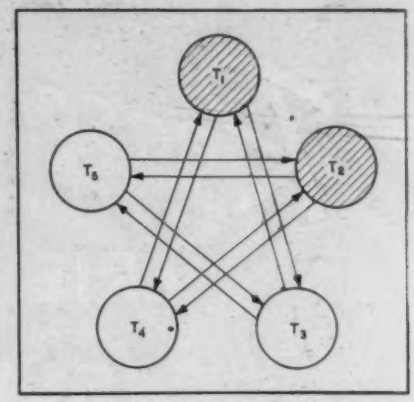
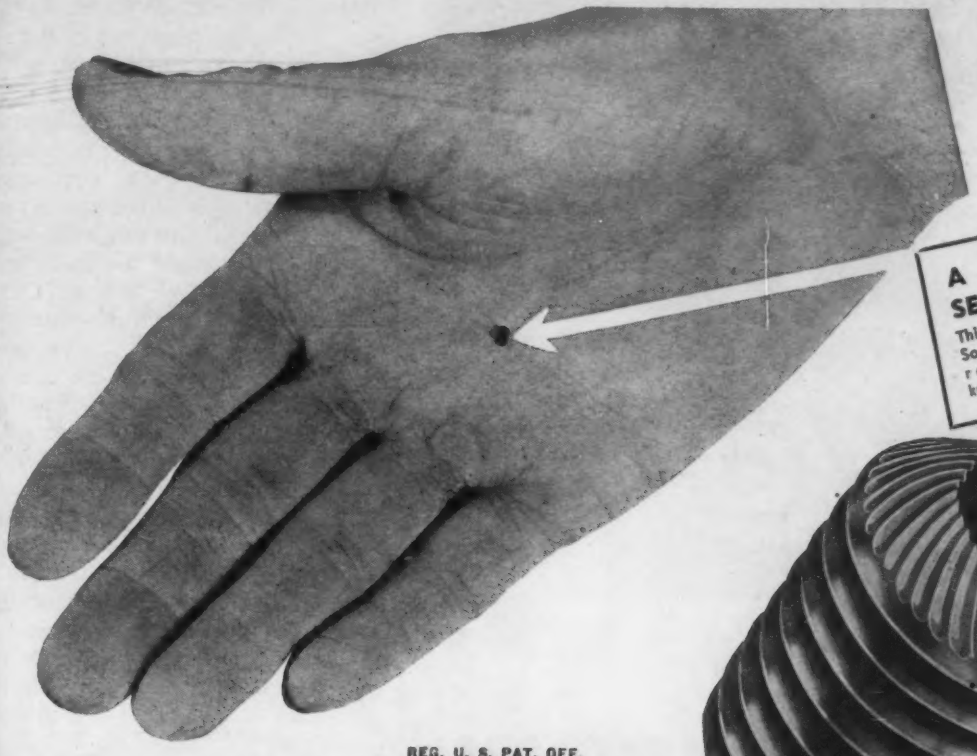



**FIG. 4—Whereas the circuit of Fig. 1 has five stable states with but one tube conducting in each state, this circuit has five stable states but with two tubes conducting in each one**

ing used to decouple the switching grids from the rest of the circuit.

The diode-triode circuit can be used as a decade counter by letting $N$ equal ten. However, ten triodes and 90 diodes (50 if the triodes are cut off in groups and subgroups) are somewhat impractical. A more satisfactory decade counter can be obtained by combining a scale of 5 and a scale of 2 circuit in much the same way that two scale of 2 circuits are combined to form a scale of 4 circuit. Neon bulbs can be connected in each tube circuit and the count calculated by addition, or ten bulbs can be connected so that only one lights for each of the ten combinations of positions of the two counter circuits. Such a circuit is shown in Fig. 5. With the circuit in the condition shown, only one neon bulb is across sufficient voltage to light. Input pulses are applied to the scale of 2 circuit and an output pulse from it triggers the scale of 5 circuit every other time the scale of 2 circuit is pulsed. The bulbs light in sequence. An output pulse from the scale of 5 circuit can be used to operate additional counters. The circuit is reset to zero by the push button that turns on tubes $T_2$ and $T_5$ by grounding their grids.

In the particular application for which this circuit was developed, as mentioned in the beginning, both the scale of 2 and the scale of 5 circuits are triggered simultaneously, the bulbs lighting in the sequence 0, 3, 4, 7, 8, 1, 2, 5, 6, 9, 0, 3, . . . but are renumbered to count successively from 0 to 9. These same circuits can be used as elec-



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Each has the KNURLED Cup Point that makes them "Unbrako" Self-Lockers, because the knurled points dig-in and stay dug—regardless of the most chattering vibration. Yet, they can be used over and over again, so everything considered, it's no wonder that untold millions are being used throughout industry.

Each has the internal wrenching feature that facilitates high torques, compact designs, weight- and space-saving. Available in sizes from #4 to 1½" in diameter.

Write for your copy of the "Unbrako" Catalog. It describes these and other "Unbrako" Socket Screw Products.

**"Unbrako" and "Hallowell" Products are sold entirely through Industrial Distributors.**

**Knurling of Socket Screws originated with "Unbrako" in 1934.**

Knurling the threads of this "Unbrako" Socket Set Screw, as shown, turns it into a most excellent Self-Locker—for use where the points such as: flat, dog, cone and oval do not lend themselves to knurling.

Pat'd and Pats. Pend.

The "Unbrako" Socket Head Cap Screw is a time-saver. Its knurled head provides a slip- and fumble-proof grip, even though the fingers and head be ever so oily, therefore, it can be screwed-in faster and farther before it becomes necessary to use a wrench.

You can't screw socket screws in or out without a hex socket wrench, so why not get our No. 25 or No. 50 "Hallowell" Hollow Handle Key Kit which contains most all hex bits.

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## SORENSEN SYSTEM NOW APPLIED TO DC VOLTAGE REGULATION

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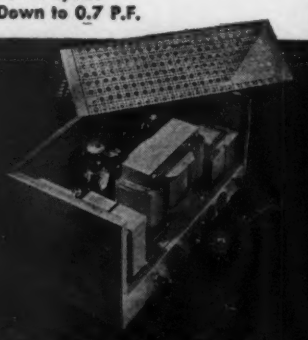
This same electronic regulation system has been incorporated into the Nobatron, providing a source of regulated DC voltage at currents and stabilities that, in the past, was available only with batteries.

This new source of stabilized DC voltage is obtainable in six standard models operating on a 95-125 AC source of 50 to 60 cycles.

Among the more important uses for Nobatrons are DC ammeter calibration in experimental and quality control laboratories, testing of components in the automotive and aircraft industries in battery-operated relays and in other applications where it is desirable to replace a battery to guarantee continuous regulated power supply.

**GENERAL AC REGULATOR SPECIFICATIONS**

| | | |
|---|---|---|
| Input Voltage Range | (—1 model) | 95-125 |
| | (—2 model) | 190-250 |
| Output Voltage Range | (—1 model) | 110-120 |
| | (—2 model) | 220-240 |
| Load Range | | 25-30,000 V. A. |
| Regulation Accuracy | | ½ of 1% |
| Harmonic Distortion | | 5% Max. (2% in "S" Models) |
| Input Frequency Range | | 50-70 cycles |
| Inductive Power Factor Range | | Down to 0.7 P.F. |



For standard voltage regulation, Sorensen Model 500 is a proven leader in its field—compact, accurate and dependable. This model typifies the Sorensen line of AC and Nobatron all-purpose voltage regulators. Let a Sorensen engineer help you with your next voltage regulation problem.

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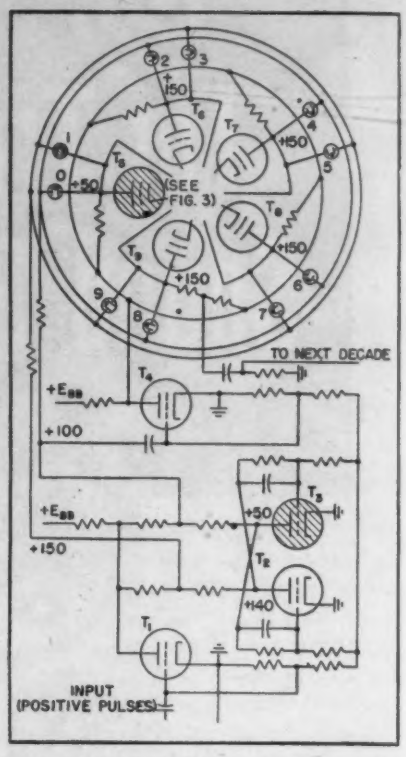


**FIG. 5—A scale of ten counter can be built using a scale of two and a scale of five circuit**

tronic switches such as are frequently used in presenting simultaneously several phenomena on an oscilloscope, or for high-speed commutation of several signals in time division multiplex systems.


(1) W. H. Eccles, and F. W. Jordan, *Radio Review*, 1, 143, 1919.
(2) Byron E. Phelps, Dual Triode Trigger Circuits, ELECTRONICS, p 110, July 1945.
(3) Harold Lifshutz, and J. L. Lawson, A Triode Vacuum Tube Scale-of-Two Circuit, *Rev Sci Inst*, 9, 83, 1938.
(4) Harold Lifshutz, New Vacuum Tube Scaling Circuit of Arbitrary Integral or Fractional Scaling Ratio, *Phy Rev*, 57, 248, 1940.
(5) John T. Potter, A 4 Tube Counter Decade, ELECTRONICS, p 110, June 1944.
(6) Victor H. Regener, Decade Counting Circuits, *Rev Sci Inst*, p 185, May 1946; also Gregory Shea, Electronic True Decade Counters, *Elect Ind*, p 82, Sept 1946.
(7) I. E. Grosdoff, Electronic Counters, *RCA Review*, p 438, Sept 1946; also S. S. West, An Electronic Decimal Counter Chronometer, *Elect Engr*, Jan 1947.


## Using A 959 as Electrometer Tube

THE READILY AVAILABLE 959 acorn tube gives excellent results as an electrometer tube if used in the following way: (1) the suppressor is used as the control grid, (2) the plate is operated at 6 volts above the filament, (3) the screen is operated at 12 to 15 volts above the filament, and (4) the first grid is con-

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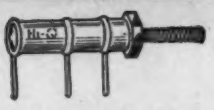

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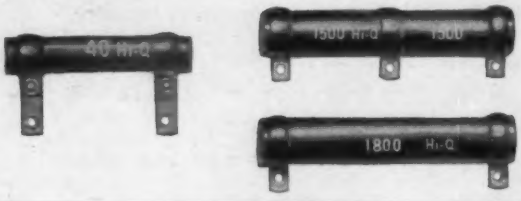
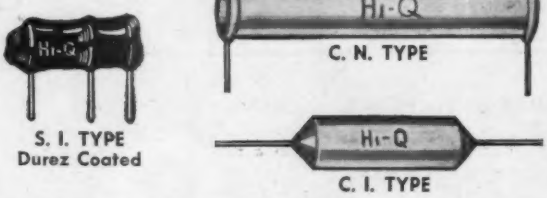
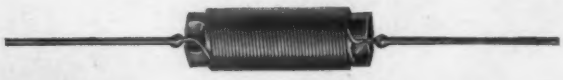



CERAMIC CAPACITORS




CHOKE COILS



Hi-Q ELECTRICAL REACTANCE CORPORATION
FRANKLINVILLE, N.Y.



nected directly to the filament. Under such conditions the grid current is only $10^{-13}$ to $10^{-12}$ amperes. Output is obtained across a 0.25-megohm resistor in the plate circuit.

To maintain the input resistance at or above $10^{13}$ ohms, the socket clip is removed and the connection soldered directly to the tube lead, and the tube dipped in ceresin wax to eliminate surface leakage. (Silicone treatment could also be advantageously used for this purpose as moisture condensing on it also does so in droplets and it is stable over a wide temperature range.) Stability of the tube can be improved by operating the filament from a regulated power supply, most conveniently the same one supplying high voltages for the associated amplifier, and at only 42 to 44 ma. The voltages for the screen and plate are obtained from dropping resistors in the filament supply, thus introducing a feedback effect that also improves stability. By placing a photocell between screen and suppressor, a light-controlled circuit is obtained. Either method of operation has a variety of applications. (PB 49579)

## Experimental Ignition Systems

IGNITION SYSTEMS, especially in aircraft, have several faults. Burning of distributor and interrupter contacts and of spark-plug electrodes limits the life of components, and high voltages on the distribution system are difficult to control, corona being particularly troublesome at high altitudes.

To overcome these and other troubles, electronic (G. V. Eltgroth, Electronic Ignition Systems, ELECTRONICS, p 106 April 1945) and other high-frequency (ELECTRONICS, p 264 Dec 1945) ignition systems have been tested. During the war, several ignition systems were experimentally developed in Germany.

The system developed at Bosch is illustrated in the accompanying drawing. The charge from the capacitor is passed through the hot cathode, hydrogen filled tube either to the distributor and thence to individual stepup transformers on

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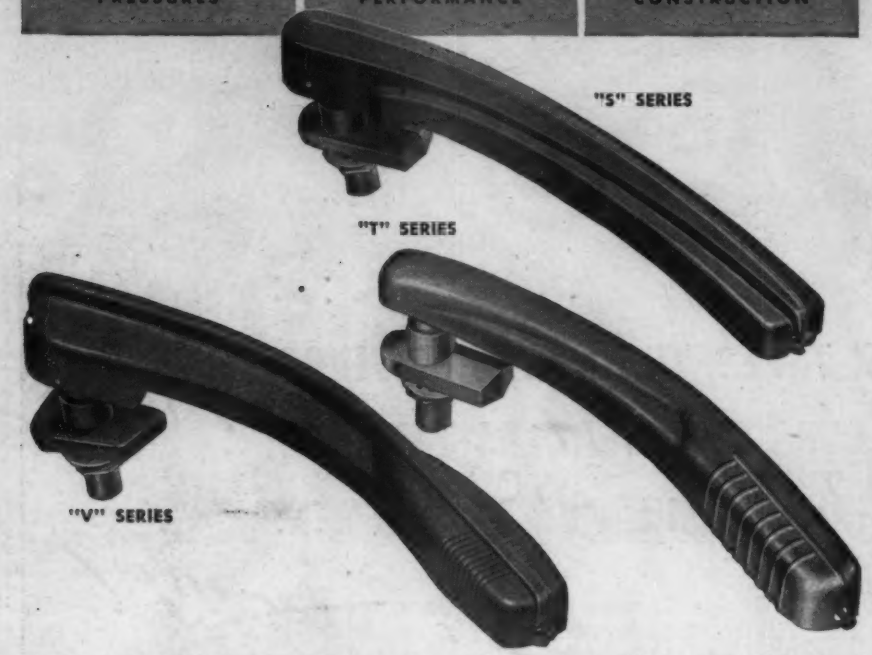


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Additional points that describe their merit are as follows:

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- Low Record Wear
- Easy to Install
- Feather-light Tracking
- High Needle-point Compliance
- Accommodates Various Needles
- All Voltage Requirements
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The "S" Series is finished in rich brown, the "T" Series in fawn and the "V" Series in bronze.

Already adopted by many leading record player manufacturers for new models, they offer the finest in styling, performance and dependability.

A complete selection of cartridges is also available for the above line as well as for use with other makes of tone arms.

SERIES "S"—Sturdy die-cast zinc alloy construction with spring counterbalance maintains tracking pressure at only one ounce. Meets majority of requirements.

SERIES "T"—Stamped aluminum construction without counterbalance or springs. Internally braced to give maximum rigidity and freedom from resonance distortion. Tracking pressure 1¼ ounce.

SERIES "V"—Aluminum die-cast construction, a deluxe model with high lateral ridge to assure absolute minimum in resonance distortion. Tracking pressure ¾ ounce.

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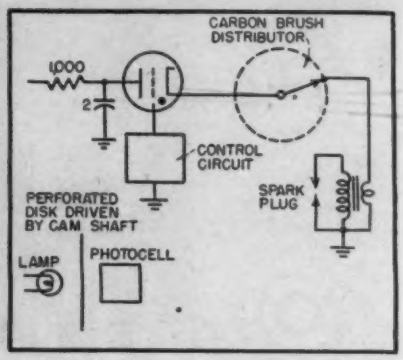



**Electronic impulse ignition system has accurate timing**

each sparkplug, or to a single stepup transformer and then to the spark plugs, the former being preferable as the distributor operates at lower voltage. The control circuit consisted of a perforated disk driven from the engine shaft, a light, photocell, and amplifier tube. The battery voltage in the vehicle was stepped up to 400 volts for use on the tubes. The system performed satisfactorily, but the transformers on the spark plug were unnecessarily large; timing was very good (PB 22653). The Bosch company also developed superior flywheel magnetos which generated voltages for both ignition and lighting (PB 34724), and experimented on high-frequency ignition systems with negative results (PB 32589).

Other German ignition research was directed toward developing a low-voltage system. The basic technique was to guide the spark between electrodes along an insulator. A ceramic tube served best for operation from 400 to 2,500 volts (PB 18891 and PB 12641). Elsewhere in Germany chemical ignitors were tested but with unsatisfactory results (PB 6679 and PB 13845).

## Millimeter Wavelengths

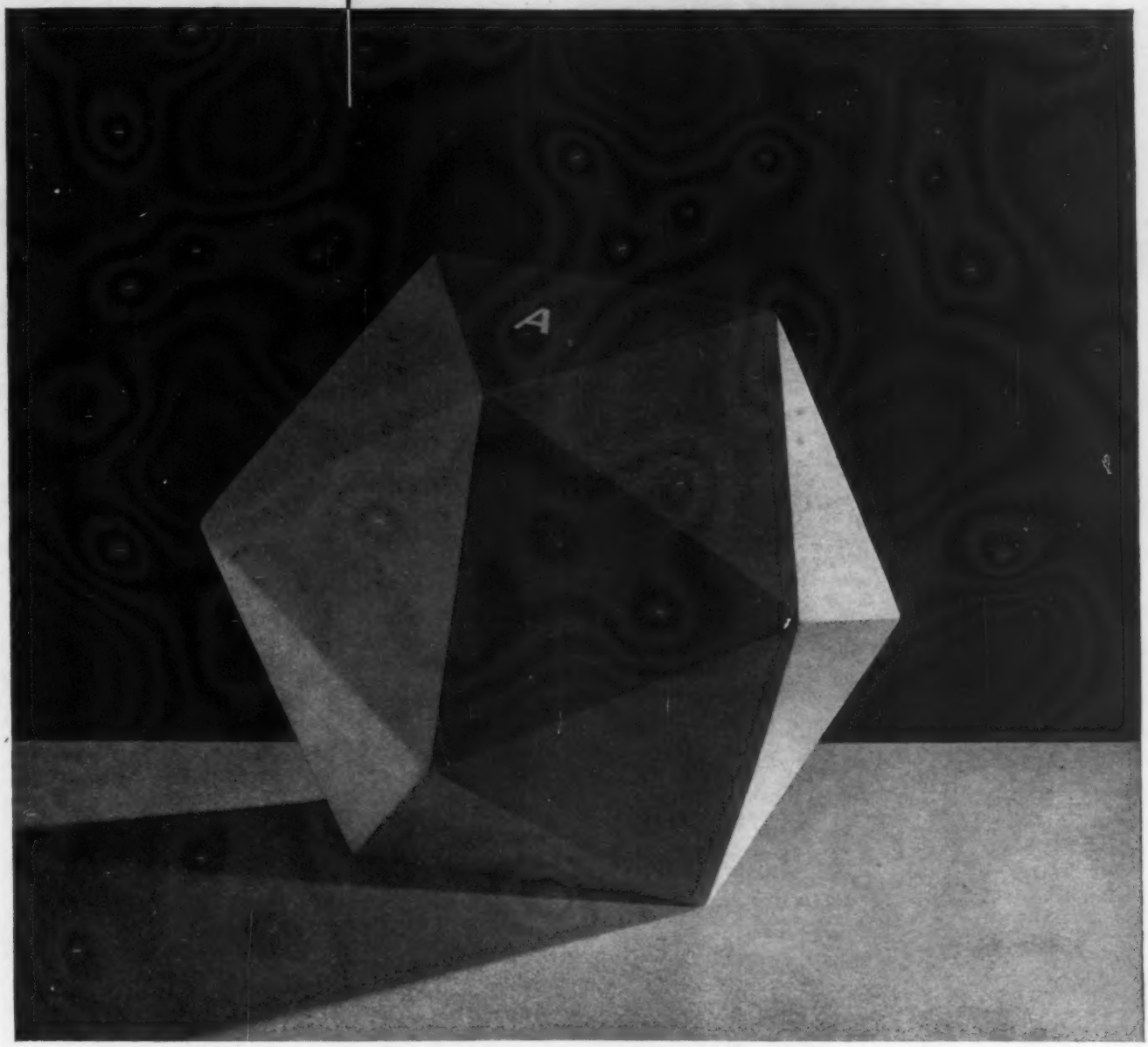
GENERATION of extremely high-frequency electromagnetic waves is done by several methods. Although the energy available at millimeter wavelengths is small compared to energies used in microwave communicational and navigational equipments, it is sufficient for laboratory studies. Furthermore, although there are limitations to the maximum frequency at which a given energy can be generated,

# It tells when you will telephone

"It" is an icosahedron—a solid with twenty regular faces. The laws of probability say that if you roll a hundred icosahedrons on a table, eleven or more will come to rest with side "A" on top only once in a hundred throws.

Identical laws of probability rule the calls coming into your local Bell Telephone exchange. Suppose you are one of a group of a hundred telephone subscribers whose practice is to make one three-minute call each during the busiest hour of the day. The chance that eleven or more of you will be talking at once is also only one in a hundred. Thus it would be wasteful for the Bell System to supply your group with a hundred trunk circuits. Eleven trunks will suffice to give you good service.

Telephone traffic conditions vary. But you can be sure, wherever you live, that Bell Telephone Laboratories research, which pioneered in applying probability theory to telephone traffic, is everywhere helping to make the most use of costly equipment.

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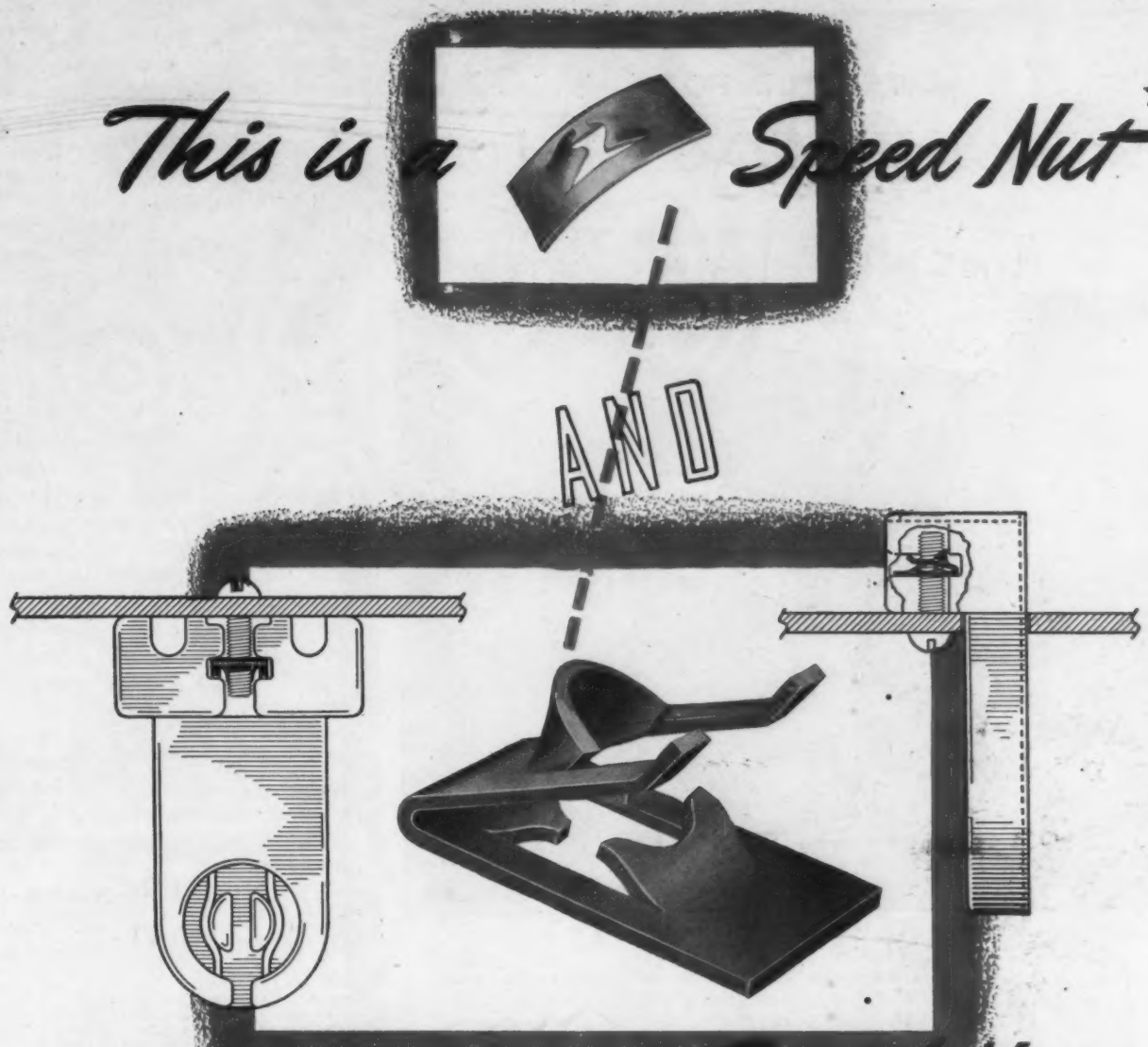
# This is a Speed Nut*




# THIS is also a Speed Nut

● Here is a self-retaining, self-locating and self-locking SPEED NUT designed for fluorescent tube lamp sockets. But it's merely one of hundreds of special shapes that do more than merely hold the screw.

This SPEED NUT C6800 is zipped into the recess in the lamp socket to stay. The turned up ends of the spring arms "bite" into the plastic to lock the SPEED NUT firmly in place. It is self-locating because the extruded collar butts up against the back of the vertical slot to line up the SPEED NUT impression with the screw hole. It's self-retaining and self-locking because of the exclusive spring tension lock of the SPEED NUT Brand of fasteners. Fits any socket of this type using standard 6-32 machine screws.

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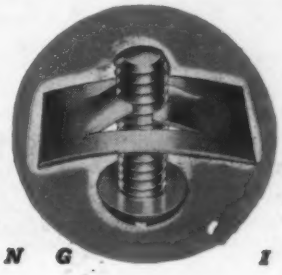

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these limitations can be circumvented. The limitation of power that can be stored in a small cavity is circumvented by using multicavity magnetrons and by forcing the magnetron into oscillations at which the cavities are several wavelengths long, as in the Rising Sun magnetron.[1] The beam traveling-wave tube[2] provides a means of exchanging energy between beam and electromagnetic circuit that eliminates the resonant circuit altogether, and with it the difficulty of coupling energy into the resonant circuit, usually a cavity.

A reflex oscillator was built following an analysis of factors limiting the output power at millimeter wavelengths[3]; it delivered several

**Table of Methods of Generating Millimeter Wavelengths**

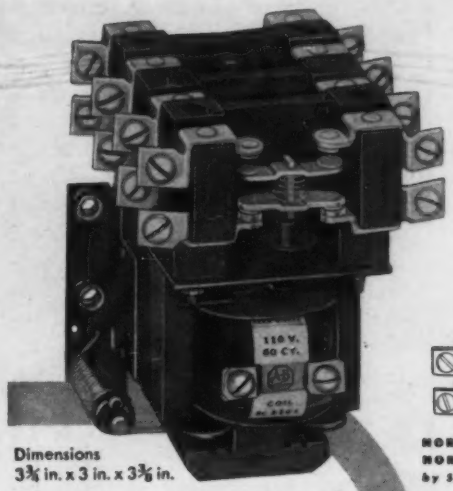
| Generator | Wavelength in millimeters | Output |
|---|---|---|
| Split anode Magnetron[4] | 6.4 | continuous |
| Pulsed klystron (0.01 duty cycle)[5] | 5.80 to 4.15 | pulsed |
| Second harmonic of 1-cm klystron[7] | 6.1 to 5.4 | continuous |
| Shock excitation of metal particles[6] | 2.2 to 0.2 | damped |

milliwatts at 5 mm. The major problem is to focus a sufficiently high-current beam through the apertures in the resonator. If the apertures are made large, the r-f field does not extend across them with the result that there is no coupling between electrons at the center of the beam and the electromagnetic field across the apertures The aperture must therefore be made fairly small, which means forcing the dense beam of electrons into a small cross section against the mutual repulsion of the electrons. A compromise design was adopted using very fine grid wires across a small aperture. The wires were thin enough not to block the beam, but thick enough to dissipate the heat generated by electron bombardment and to have enough r-f conductivity to justify their use. The pulsed output of the tube was detected by a 1N26 crystal.

Earlier investigators generated millimeter wavelengths by magne-

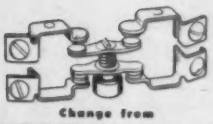
# RELAYS

## for Electronic Circuits



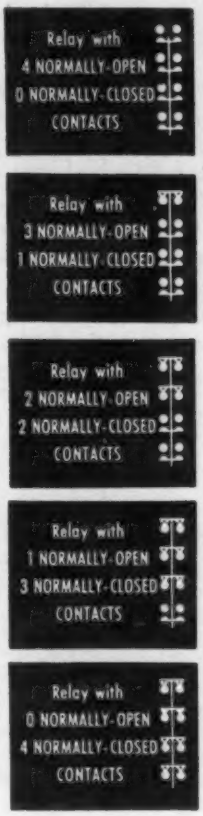
Dimensions
3¾ in. x 3 in. x 3⅜ in.

**BULLETIN 700 UNIVERSAL RELAYS** are a new and important addition to the standard line of Allen-Bradley solenoid relays with a 10-ampere rating. These universal relays have two banks of contacts which permit quick and easy changes from NORMALLY OPEN TO NORMALLY CLOSED contacts ... or vice versa ... merely by shifting terminal connections. (See diagrams at left.) They are ideal for electronic applications in which circuit connections must be interchangeable to meet varied operating conditions. Available in 2, 4, 6, and 8 poles, with double break, silver alloy contacts which need no maintenance. There are no pins, pivots, bearings, or hinges to bind or stick. Hence, these relays are good for millions of trouble-free operations in electronic service. Send for bulletin, today.

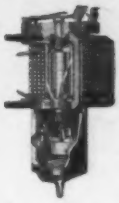


Change from NORMALLY-OPEN Contacts to NORMALLY-CLOSED Contacts by Simply Shifting Connections

*Typical Contact Connections*




### OTHER ALLEN-BRADLEY RELAYS & CONTACTORS



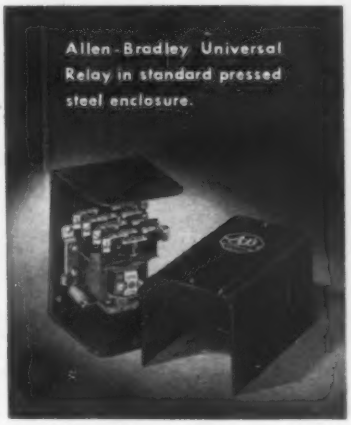
**BULLETIN 810 TIMING RELAYS** are ideal for any service requiring an adjustable delayed action relay. Have normally open or normally closed contacts.

Magnetic solenoid core is restrained from rising by the piston in oil dash-pot. Adjustable valve in piston regulates time required to pull piston through oil-seal and trip the contacts, which open or close with quick, snap action. Ideal for transmitter plate voltage control.

**BULLETIN 702 SOLENOID CONTACTORS** for heavy duty ratings up to 300 amperes. Arranged for 2- or 3-wire remote control with push buttons or automatic pilot devices.

Enclosing cabinets for all service conditions. Double break, silver alloy contacts require no maintenance. Solenoid mechanism is simple and trouble-free.

Allen-Bradley Co.
110 W. Greenfield Ave.
Milwaukee 4, Wis.



Allen-Bradley Universal Relay in standard pressed steel enclosure.

A-B Quality

**ALLEN-BRADLEY**

**RESISTORS** **RELAYS**

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TEAMED FOR

*PERFECT HEARING COMFORT*

Thousands of secretaries have long exclaimed, "Oh! For a transcribing machine with *comfortable* headphones."

And here's the perfect answer to this need . . . the new TELEX Monoset . . . now standard equipment on the Gray Manufacturing Company's new transcribing machine, the Gray Audograph. This modern under-the-chin headset is light in weight, comfortable and *instantly adaptable to the user.* There is no ear fatigue, no more mussed up hair with the TELEX Monoset . . . and it gives a new kind of performance that means improved work and improved disposition. Its electro-acoustic "heart" assures faithful sound reproduction. Its rugged plastic construction assures years of service. Yes, the TELEX Monoset teamed with the new Gray Audograph is another example of "perfect hearing comfort."

*Write Department AM for information and quotations. We'll be happy to show you how the TELEX Monoset can become part of your team for perfect hearing comfort wherever headphones are needed.*

**SPECIFICATIONS**

**Impedance:** 2000 ohms—Part No. 2568
500 ohms—Part No. 2569
128 ohms—Part No. 2570

**Sensitivity:** 88 d.b. above .000204 dynes per square centimeter for 10 microwatt input.

HEARING AT ITS BEST
TELEX INC.
ELECTRO-ACOUSTIC DIVISION
TELEX PARK
Minneapolis, Minn.

*Canadian Distributors:*
**Addison Industries Ltd., Toronto**



trons and spark discharges. A split anode magnetron of 0.19 mm. anode radius operating at 1,200 volts in a magnetic field of 24,000 oersteds developed $4 \times 10^{-9}$ ma in an iron purite crystal receiver placed at the focus of a mirror located 15 meters from the tub. The wavelength was measured with an echelette grating spectrometer. Spark discharges between spheres produce oscillations at an approximate wavelength of $2\pi d/\sqrt{3}$ where $d$ is the diameter of the sphere. This technique was used to obtain radiation for biologic studies.[5] A similar method is to shock excite aluminum dipoles in a flowing stream of oil. The energy so produced is detected by a thermocouple and the wavelength measured with wire gratings.[6] Although the power from these oscillations is low, it is sufficient for such physical measurements in the laboratory as the absorption of electromagnetic waves by gases in the study of intermolecular forces.[7] Refinements in present techniques and new techniques may push the frequency limits higher.

(1) Rising Sun Magnetron, ELECTRONICS, p 202 Aug. 1946. Brief description of magnetron design developed at Columbia University Radiation Laboratory.

(2) Wideband Microwave Amplifier Tube, ELECTRONICS, p 90 Nov. 1946. Characteristics and operating principles of beam traveling-wave tube.

(3) Lafferty, J. M., A Millimeter-Wave Reflex Oscillator, *J. of Appl. Phys.*, p 1061 Dec. 1946. Based on analysis of factors affecting frequency limitation of reflex oscillators, tubes to give very short wavelength were built and tested. See also Pierce, J. R., Physical Limitations in Electron Ballistics, *Bell Syst. Tech. J.* p 305 July-Oct. 1945.

(4) Cleeton, C. E. and Williams, N. H., The Shortest Continuous Radio Waves, *Phys. Rev.*, p 1091 Dec. 1936. Letter to the editor describing a split anode magnetron.

(5) Montani, Angelo, A Generator of Damped Microwaves, ELECTRONICS, p 115 Sept. 1944. A half watt at 7,000 mc is produced from an array of metallic spheres.

(6) Cooley, Jean P. and Rohrbaugh, John H., The Production of Extremely Short Electromagnetic Waves, *Phys. Rev.*, p 296 May 1945. An abstract of this paper appeared in ELECTRONICS, p 298 Sept. 1945.

(7) Beringer, Robert, The Absorption of One-Half Centimeter Electromagnetic Waves in Oxygen, *Phys. Rev.*, p 53 July 1946. Output from one-cm klystron was fed into a silicon-tungsten crystal which produced second harmonic output for these absorption measurements.

## Thermal-Magnetic Control

APPARATUS OR PROCESSES depending on temperature for proper operation can be controlled at any temperature between 180 F and 1,000 F by Curie Point alloys. These are alloys of iron in proportions to obtain the required Curie point. Below

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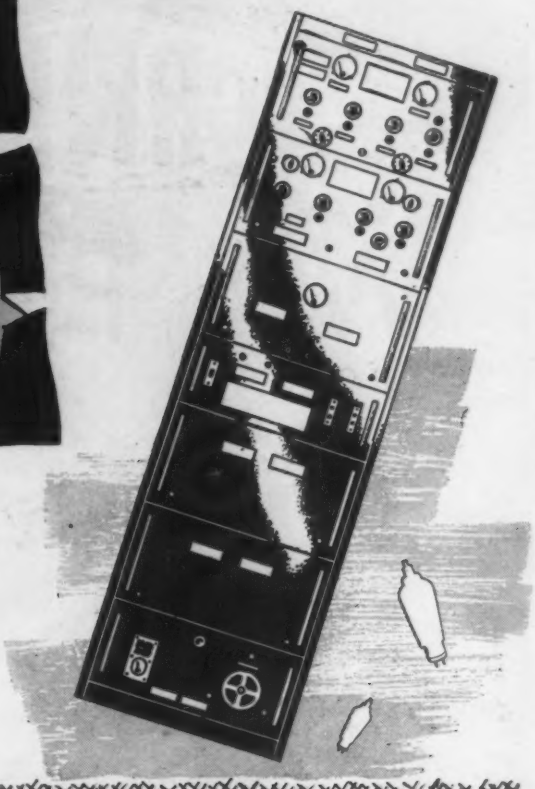

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Huge inventories, declared surplus by the Armed Forces, have been allocated to these Approved Distributors for efficient disposal.

The names and addresses of our distributors are listed below. They are equipped to serve your needs and will know what is immediately available.

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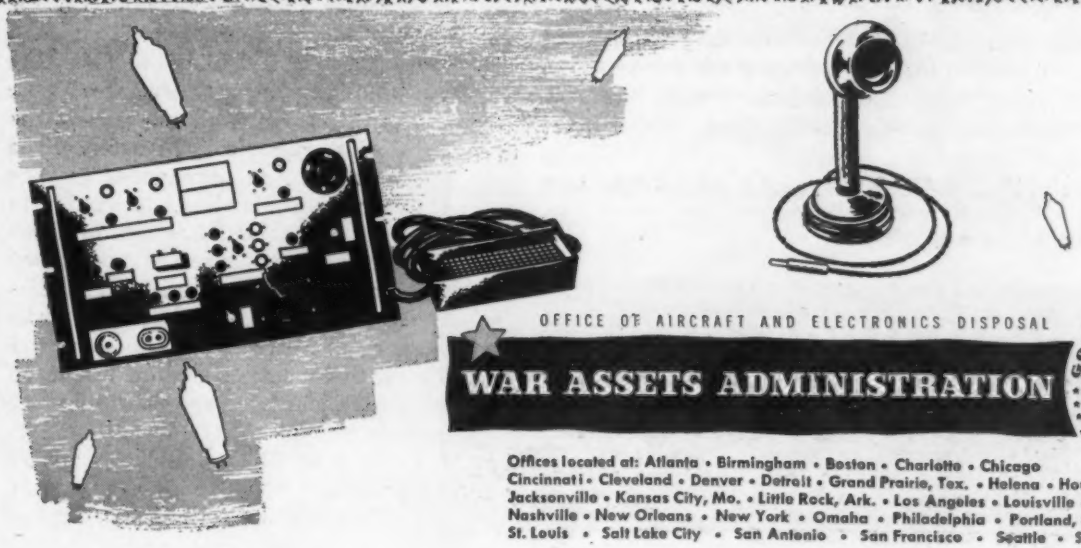

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## PERMANENT PERFORMANCE

- Kester Cored Solders are scientifically manufactured to provide permanent, dependable results in every type of soldering operation. They equip your product with rugged staying power—protect against service difficulties.
- Kester Cored Solders are simply and easily applied. Self-contained fluxes are positive-acting and will not disintegrate or lose their fluxing power.
- Kester Rosin-Core Solder, for electrical work, contains a patented plastic rosin flux. Ideal material for clean, tight electrical connections, Kester Rosin-Core Solder will not cause corrosion or injure insulation.
- For general soldering, use Kester Acid-Core Solder to safeguard the equipment you build . . . with tight, trustworthy solder bonds.
- Kester engineers are at your service, to help you select the right solder, and the correct strand and core-size for every operation. Write them fully; there is no obligation.

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*Cored Solders*
STANDARD FOR INDUSTRY



this point the alloys are ferromagnetic having high permeability, above it they are paramagnetic having very low permeability. The transformation temperature is fixed by the alloy composition and is unaffected by other factors. These metals, prepared by the Curie Point Alloys Co. (Chicago), can be used in magnetic circuits to provide control. For example the metal can be the armature of a relay. While below its Curie point it will be attracted by the relay's magnetic field, but if heated above the Curie point, it will no longer be so attracted. The transformation from ferromagnetic to paramagnetic states is reversible and occurs in either direction at the same temperature in any given alloy.

### Developmental Television In France

SMALL TELEVISION CAMERAS and high definition pictures are being developed in France. The equipment furthest toward application is the 819 line system of La Radio-Industrie featuring a new iconoscope with a primary image only one square centimeter in area. This camera, called the Eriscope, uses 16-mm movie camera lenses giving a depth of field from two meters to infinity without refocusing. It can

Television camera is as maneuverable as a newsreel camera

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WIRES

*at work*

*Courtesy HURLEY Machine Division, makers of GLADIRONS*

**WHY ARE CORNISH WIRE PRODUCTS SPECIFIED BY THIS LARGE MANUFACTURER OF IRONING MACHINES?**

Because their ENGINEERING Department knows by test that they will give faithful and enduring performance . . .

Because their PRODUCTION Department finds that they have those qualities essential for quick installation on their assembly line . . .

Because their PURCHASING Department realizes that these Quality Products, backed by dependable service, are sold at prices that spell true economy . . .

**CORNISH WIRE CO., INC.**

15 Park Row • New York City, 7



be used for normal outdoor shooting at intensities down to 500 lumens. The tube is now built of Pyrex; when molybdenum glass is available it is expected that the primary image size can be reduced to 64 square millimeters. The camera also houses a preamplifier and final stages of the sweep circuits, the generators and frequency dividers being in the fixed studio equipment.

Transmission of the doubly interlaced picture at 50 half frames per second will be at 200 mc from a transmitter to have a peak power of 1 kw. Synchronizing pulses are to be transmitted by a-m, the 10-mc picture band by f-m, and the sound by f-m on a separate 200 watt transmitter with a maximum swing of ± 75 kc and an a-f band from 30 to 15,000 cps.

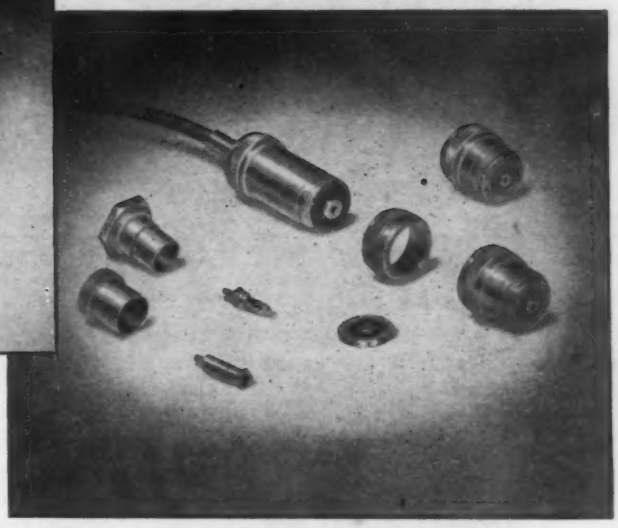
Other French firms are experimenting on high definition, the system of the Compagnie des Compteurs having 1015 lines. The government-owned Television Francaise has resumed experimental daily broadcasting from its 30-kw Eiffel Tower transmitter with the prewar 450-line picture.

## Survey of New Techniques

A DEVICE has been developed at Wright Field that enables a plane to fly a straight line. It operates from shoran signals and is being used in aerial mapping to permit the photoairplane to follow a straight course in taking a sequence of photographs of a large area. The Straight Line Indicator can either provide instrument indication for the pilot or operate an autopilot.

Electrical drilling of dies has been independently developed at the U. S. Bureau of Standards and the Soviet Electrical Institute. The technique as developed at the Bureau of Standards is applied to drilling diamond dies used in drawing such fine wires as those used for vacuum tube grids. The diamond is drilled by electrical sparks formed between a needle point and the diamond. Dies for 0.0004 to 0.015 inch wires are produced in 40 hrs against about 150 hrs by conventional drilling. The electrical erosion technique developed in Russia is substantially the same but is

# for VOLTAGE MEASUREMENTS to 1,000 Mc!



The Type 1802-A Crystal Galvanometer (a "galvanometer" rather than a "voltmeter" because it does not have the high accuracy of most other G-R instruments) measures voltages from 30 to 1,000 Mc, and is useful up to 4,000 Mc. It is direct-reading from 0.1 volt to 100 volts and is finding considerable utility in u-h-f measurements.

Essentially it is very simple — a 1N21B crystal and a d-c amplifier. To obtain the high upper-frequency limit, however, several mechanical and electrical design problems are involved. The crystal rectifier extends the frequency range far above that obtained with the usual tube diode; however, the uniformity of commercially available crystals is below that of the v-t diodes and limits the instruments accuracy to ±5%.

The upper frequency limit is dependent upon the design of the pick-up probe. The probe assembly has been designed to minimize inductance by using cylindrical blocking and by-pass condensers. The probe design and the crystal itself result in an average probe resonant frequency of about 1800 Mc. Individual crystals modify this resonant frequency.

The amplifier uses a degenerative cathode-follower circuit arranged as a bridge system. The sensitivity of the meter is essentially independent of zero setting.

Two capacitance voltage dividers are supplied as multipliers extending the voltage ranges to 10 and 100 volts. Fittings for plugging into coaxial connectors are furnished.

**TYPE 1802-A Crystal Galvanometer . . . $210.00**

**WE HAVE A FEW IN STOCK — Order Now for Probable Immediate Shipment**

**GENERAL RADIO COMPANY** Cambridge 39, Massachusetts

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# MASTERPIECE

**Soundcraft discs are the culmination of a five-year engineering search for wider dynamic range, lower surface noise, freedom from "grey-cut" and "swish" in disc recording.**

**Soundcraft engineers have developed a coating process that now makes possible the application of high solid content, finer grained lacquers in an unusually thick, clean and uniform coating.**

**Check and compare these Soundcraft qualities with other blank discs you may be using now.**

**Background noise lowered 2—4 db**
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***In order that you may test for yourself our claims for Soundcraft discs, a "Broadcaster" disc will be sent without charge to anyone detaching this page and sending his name and address to us.***

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applied to drilling, slotting, or cutting hard metals.

Metal-ammonia solutions rapidly frozen to —85 C are superconductors of electricity and sensitive detectors of infrared rays. This material is a superconductor (that is, has no electrical resistance) at a higher temperature than any of the some forty other materials found to be superconductors (close to —273 C). Dr. R. A. Ogg, Jr. of Stamford University who is conducting the research on these solutions believes they may shortly be applied to infrared detection.

X-ray diffraction identification of crystals at temperatures up to 1,500 C can be done by replacing the photographic film by a Geiger counter. In the technique developed at the National Bureau of Standards the Geiger counter, which can withstand higher temperatures than film, is moved through the diffraction pattern by a synchronous motor. The pattern is recorded on a strip chart. The equipment is used in studying the modifications of crystalline states at elevated temperatures and the rates of inversion and crystal formation with powdered samples. The Bureau has designed a furnace for use with a Norelco x-ray spectrometer adapted to this study.

## PRESIDENTIAL RADIO

**Familiar equipment appears in the receiving room of the communications center that travels with President Truman and his party on the rails. Installed in a former Pullman car, the transmitters and receivers are powered by two diesel 25-kw generators**

# your Noise Problems, too can be Solved Better with C-D Quietones

Just because Mom wants to bake a cake is no reason why she shouldn't hear her pet soap opera. And sooner or later she's bound to find out that *some* mixers *don't* cause radio interference. Mixers equipped with C-D Capacitors, for example.

C-D's experience in designing and building noise suppressors is unequalled in the capacitor industry. We are now manufacturing hundreds of types of noise filters for electrical appliances and equipment. It's possible, of course, that the exact unit for solving *your* noise problem is not included. In that case, our engineers are ready and anxious to design and build the suppressor best suited to your specific requirements—*better, faster, more economically. Consult with them.*

Catalog of standard types will be mailed on request. Cornell-Dubilier Electric Corporation, Dept. K-7, South Plainfield, New Jersey. Other large plants in New Bedford, Brookline and Worcester, Mass., and Providence, R. I.

**CORNELL-DUBILIER**
world's largest manufacturer of
**CAPACITORS**

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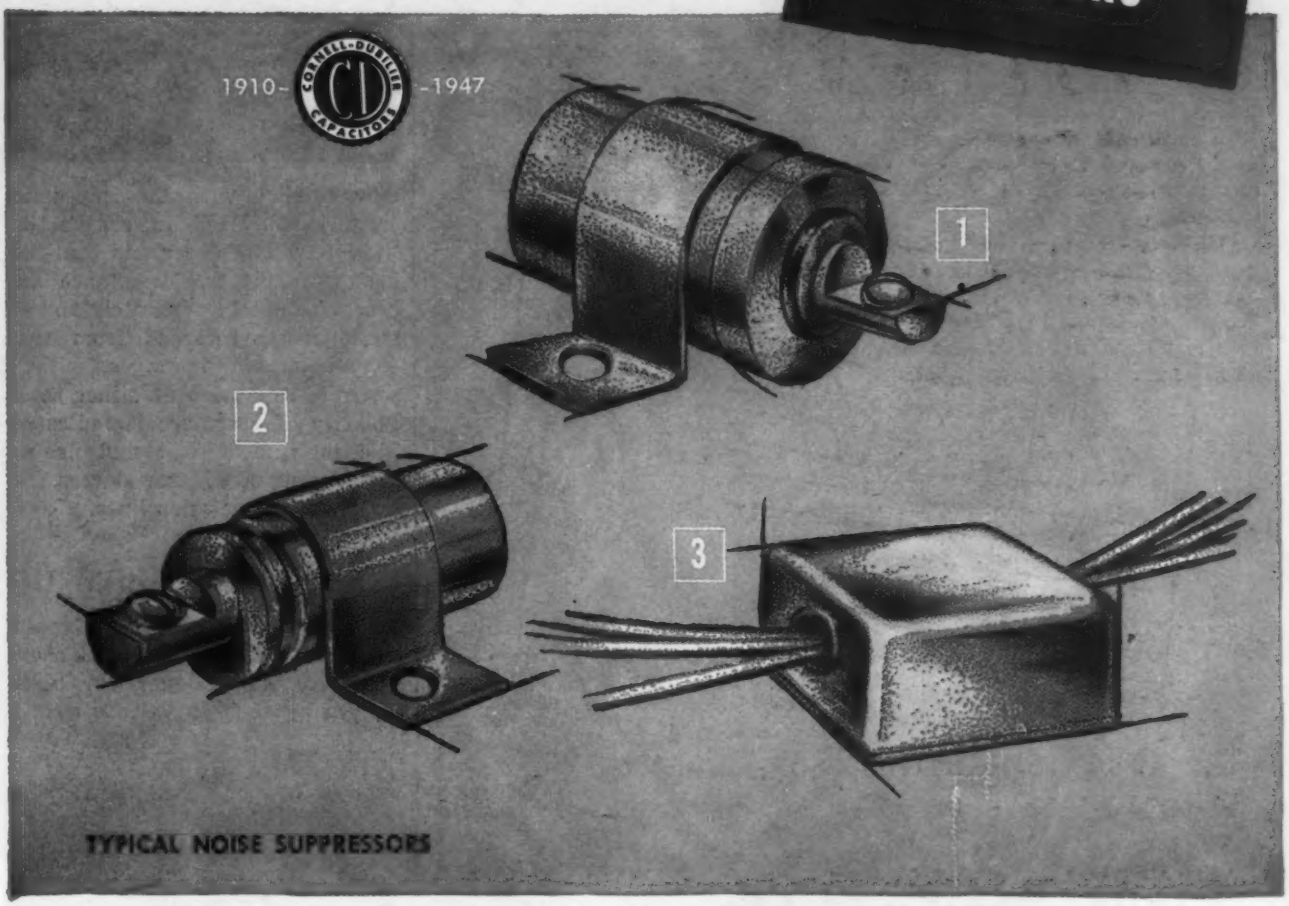


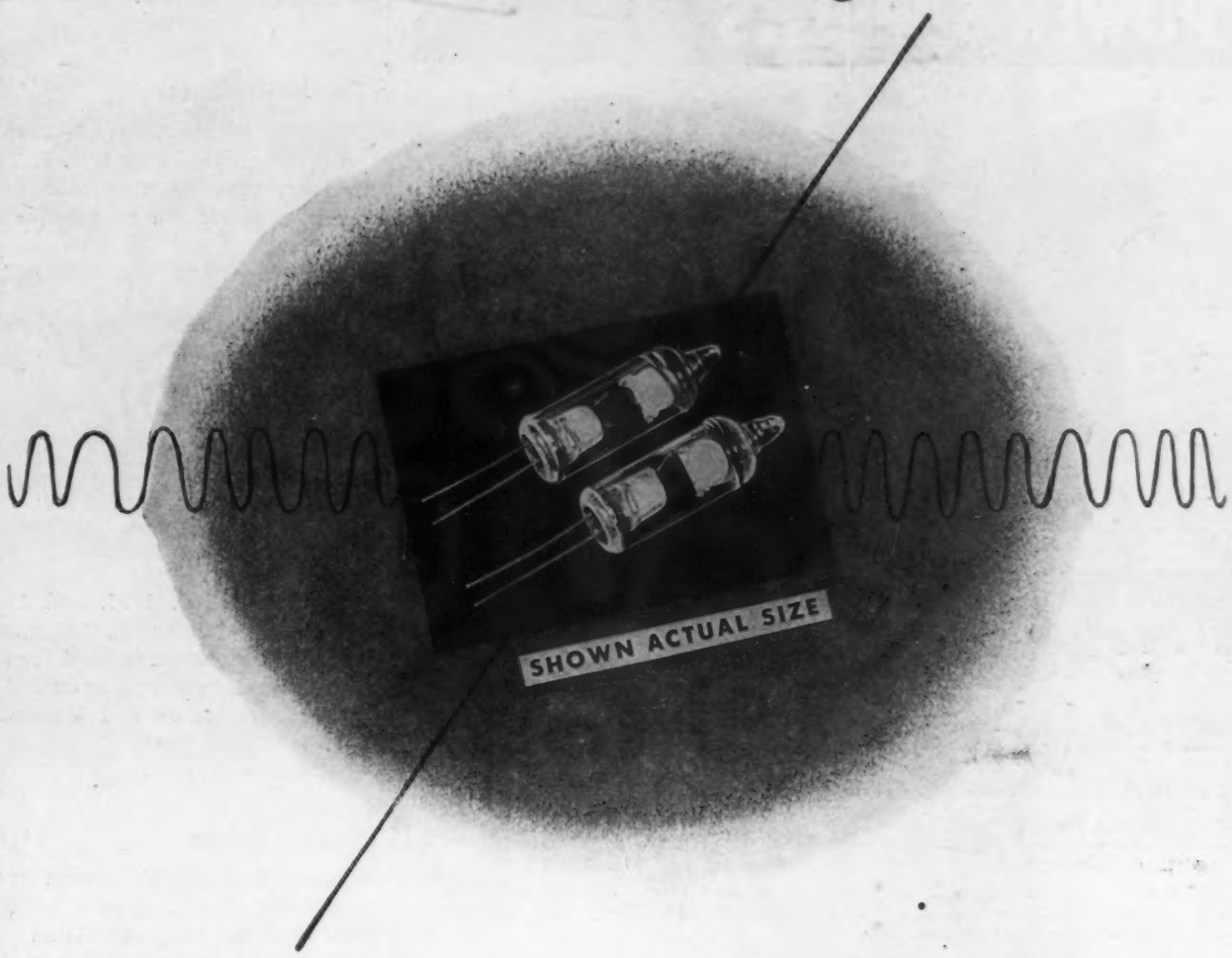

**CAPACITORS #1 AND 2**

Two of the Type MC Filter Capacitors designed for heavy duty service on buses, trucks, etc. for spark and noise suppression. Mechanically rugged, oil filled and impregnated and hermetically sealed.

**CAPACITOR #3**

A general purpose filter effectively controls radio noise energy created by fluorescent lamps. This capacitive — inductive type filter is compact and can be quickly installed in a variety of positions. Convenient leads simplify installation.

# Announcing—




# MINIGLASS QUARTZ CRYSTAL UNITS†

## For Broadcast, FM and Television Applications

These compact, hermetically sealed, high performance units are designed for your multiple applications in the range of 2,500 to 10,000 kilocycles — with a tolerance of ±250 cycles at normal room temperature.

MINIGLASS crystals are designed for low cost quantity production. Available for immediate deliveries.

*Manufacturers of Radio Quartz Crystals*

**MELVIN L. SMITH LABORATORIES**

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**KANE, PENNSYLVANIA**

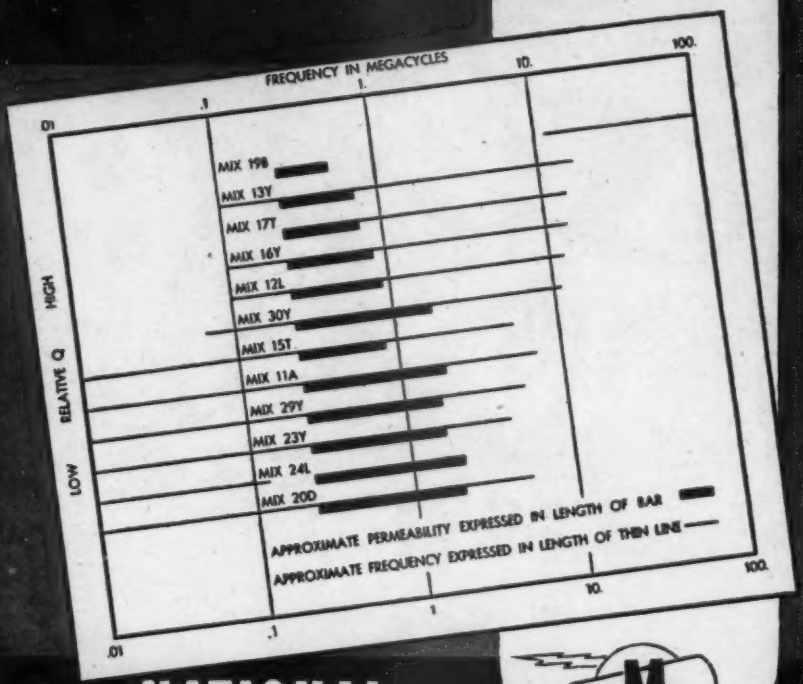
# MOLDITE IRON CORES

**SPECIALIZATION**
Moldite iron cores are produced by specialists engaged exclusively in the manufacturing of iron cores. A complete line of magnetic iron cores. For use at all frequencies including television and FM is now available.

**ENGINEERING**
It is a simple matter for Moldite engineers to fit the right core to your particular coil for the best results. Moldite engineers are thoroughly familiar with every iron core application and will be glad to assist you in determining which of these components can best satisfy your requirements.

**PRODUCTION**
With our vastly expanded production facilities, we are in the position to meet your urgent iron core requirements. Quality, economy and dependability are assured.

**SAMPLES**
Moldite sample iron cores will be submitted for design, test and pre-production purposes upon receipt of your request. Use Moldite material grade designations to insure prompt and exact duplication of the required cores. Specify "MOLDITE" for "QUALITY."

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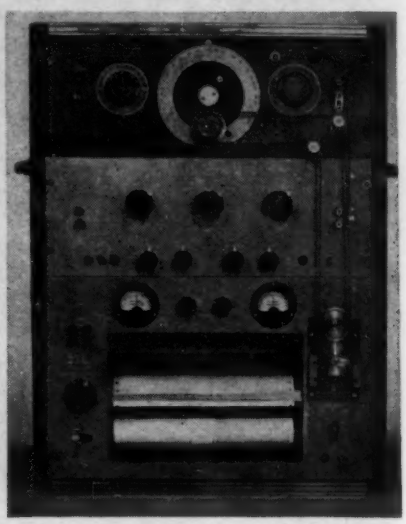
WESTERN STATES: J. J. Perlmuth Associates, 942 Maple Avenue, Los Angeles 15, California


**NEW PRODUCTS**
(continued from p 142)

plate load resistor, 250,000 ohms; grid resistor, 500,000 ohms. Further details are outlined in Bulletin 943.

## Impedance Vectorgraph (13)

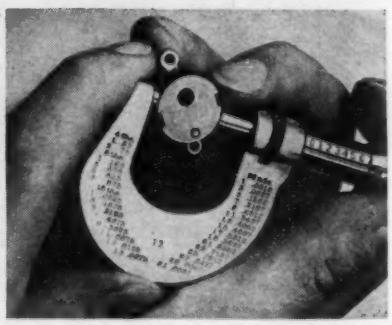
SOUND APPARATUS Co., 233 Broadway, New York 7, N. Y. A direct graphical recording of resistive and reactive components of an impedance as a function of frequency is



now possible with the Impedance Vectorgraph used in conjunction with a twin recorder and beat-frequency oscillator. Resistance and reactance can be separately and simultaneously recorded from 1 to 4,000 ohms in 6 ranges, with a separate expansion of either scale. Polarity of reactance is indicated. The instrument will find use in measurements of transducers, filters, and transmission lines.

## Dime-Size Snap Switch (14)

MU-SWITCH CORP., Inc., Canton, Mass. The Q-Switch is a small snap-action switch designed for high-current capacity in various combi-



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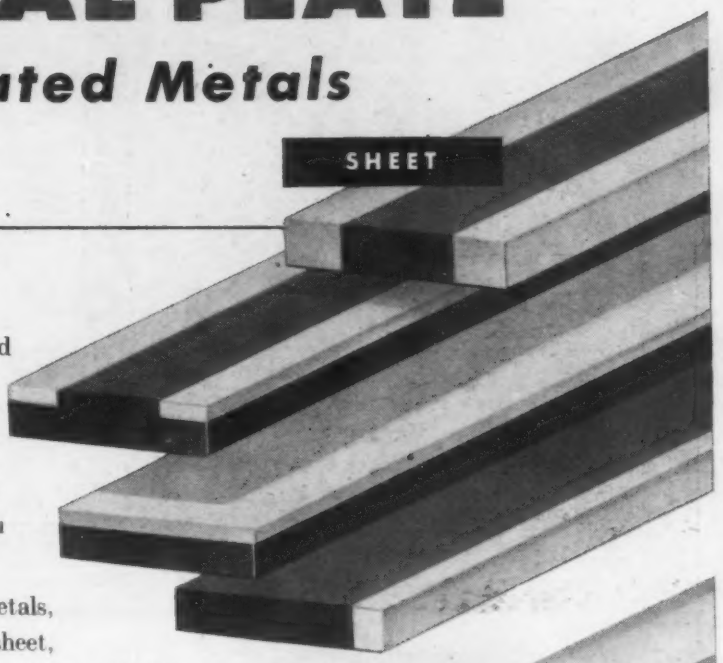
## *Laminated Metals*

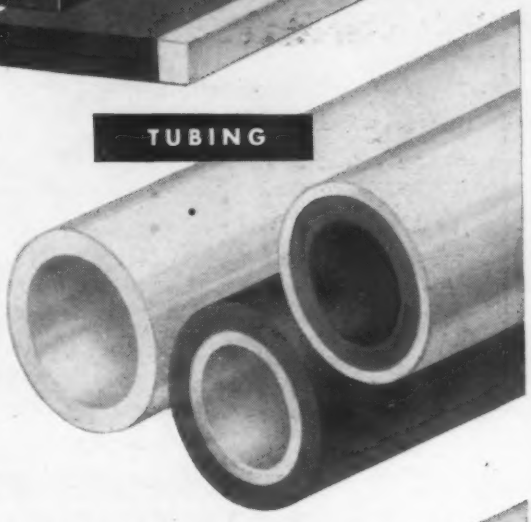
Why pay the high cost of solid silver when General Plate Laminated Metal . . . precious metal permanently bonded to inexpensive base metal . . . gives you the performance characteristics of solid silver yet costs you considerably less?

By permanently bonding silver to base metals, General Plate gives you such laminated sheet, wire and tube combinations as edgelay, inlay, wholly covered or covered one side or both. Thus you get the silver exactly where you need silver performance but without the expensive solid silver cost.

You get other advantages, too. General Plate Laminated Metals are easier to fabricate, are more workable, have better spring properties, are easier to solder, and provide structural and mechanical properties not obtainable in solid silver.

General Plate Laminated Metals are also available in many other precious to base metal and base to base metal combinations. Investigate these versatile metals. Write for information or engineering assistance.



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*of Metals & Controls Corporation*

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**ATTLEBORO, MASSACHUSETTS**

# Electronic Regulated POWER SUPPLIES

PRECISION
ACCURACY
PERFORMANCE

*Built to rigid U. S. Government Specifications*

**SPECIFICATIONS**

INPUT—115 v. 56-60 cycle

REGULATIONS—Less than 1/20 volt change in output voltage with change of from 100-140 V.A.C. input voltage & from NO-LOAD to FULL-LOAD (over very wide latitude at center of variable range)

RIPPLE—less than 5 millivolts at all loads and voltages

DIMENSIONS—Fits any standard rack or cabinet (overall: 19 in. wide: 12¼ in. high: 11 in. deep; shipping wt.—100 pounds)

TYPE A—VARIABLE FROM 210 TO 335 V. D. C. @ 400 M. A.
TYPE B1—VARIABLE—TWO RANGES: 400-600 V. D. C. @ 125 M. A. and 600-890 V. D. C. @ 125 M. A.

**CONSTRUCTION FEATURES**

Weston model 301 (or equal) milliammeter and voltmeter ● Separate switches, pilot lights, and fuses for FIL and PLATE VOLTS ● All tubes located on shockmount assemblies ● Fuses mounted on front panel and easily accessible ● Can vary voltage by turning small knob on front of panel. Can easily modify Type B1 from POSITIVE to NEGATIVE output voltage ● Individual components numbered to correspond with wiring diagram.

Rigid construction: components designed to withstand most severe military conditions—physical and electrical; were greatly under-rated.

All units checked and inspected at 150% rated load before shipment.

*Tube complement:* {Type A: 2-836; 6-6L6; 2-6SF5; 1-VR150; 1-VR105
{Type B1: 2-836; 2-6L6; 2-6SF5; 1-VR150; 1-VR105

**IMMEDIATE DELIVERY**

*NET PRICES—F. O. B. BALTIMORE, MD.*

**TYPE A—$189.00** **TYPE B1—$185.00**

Complete with tubes and ready to plug in—Prices subject to change without notice

**NATIONAL RADIO SERVICE CO.**

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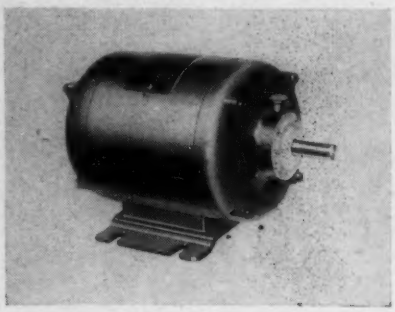
nations up to single-pole, double-throw. Its small size makes is particularly applicable in industrial electronic equipment.

### Facsimile Motor (15)

CYCLOHM MOTOR CORP., 5-17 46th Road, Long Island City 1, N. Y. The Cyclohm type 29 ventilated synchronous motor can be supplied in



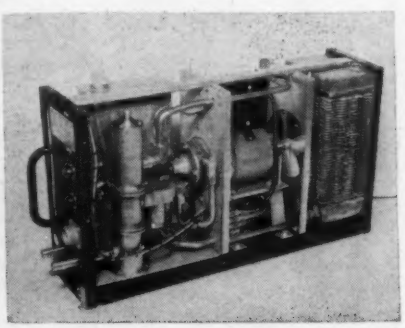
ratings of 1/100, 1/75, and 1/50 horsepower, 1,800 rpm, 115 v, 60 cps. The motors can be used for recording and tape pulling and for facsimile recorders and transmitters.

### Scratch Filter (16)

BURNELL & Co., 45 Warburton Ave., Yonkers 2, N. Y. A new scratch filter with flat response within the pass band and extremely sharp attenuation above the cutoff frequencies is adaptable to all types of recordings. Three different cutoff frequencies are provided that can be selected on a single-circuit switch.

### Heat Transfer Unit (17)

EASTERN INDUSTRIES, INC., New Haven 6, Conn. The Model No. 1 heat transfer unit, developed for



# New Crystal Pickup Achieves High Stylus Compliance

Cartridge requires less than ½ ounce stylus force. Sapphire stylus which can be removed and replaced *without tools*. Crystal protected against extremely high humidity. Withstands heat up to 250°F.

Here's a crystal pickup that sets a new high in pickup standards!

- Maximum stylus life due to highly compliant mounting and low stylus force . . . almost impossible to chip.
- Low distortion.
- Less than ½ ounce stylus force required.
- Stylus removable and replaceable without tools.
- New crystal mounting keeps crystal effective in high humidity . . . in heat as high as 250°F.
- Tests show cartridge unharmed after 15 minutes in boiling water.

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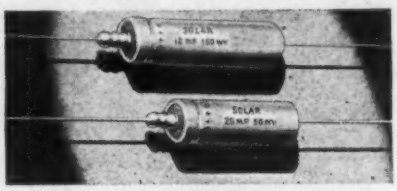
television, radar, induction heating and similar apparatus will dissipate up to 1,000 watts depending upon the operating temperature range. The unit is equipped with a four-bank radiator, cooling fan, circulating pump, reservoir, flow switch, thermostat and necessary fittings. The pump and fan are mounted on opposite ends of the same motor shaft. The motor is 1/40 hp, 3,450 rpm., 110 volt a-c induction type. The overall size is 19⅜ x 5¼ x 10½ inches high and the approximate weight is 40 pounds. The unit is encased in a black crackle finished sheet metal cabinet.

## Coating Unit (18)

NATIONAL RESEARCH Corp., 100 Brookline Ave., Boston 15, Mass. The type 3102 coating unit is a medium-size vacuum evaporator suitable for the deposition of magnesium fluoride on optics and the preparation of evaporated metal films. A dry-air pressure of $5 \times 10^{-6}$ millimeters of mercury can be obtained in nine minutes on a clean empty 18-inch glass bell jar.

## Miniature Dry Electrolytics (19)

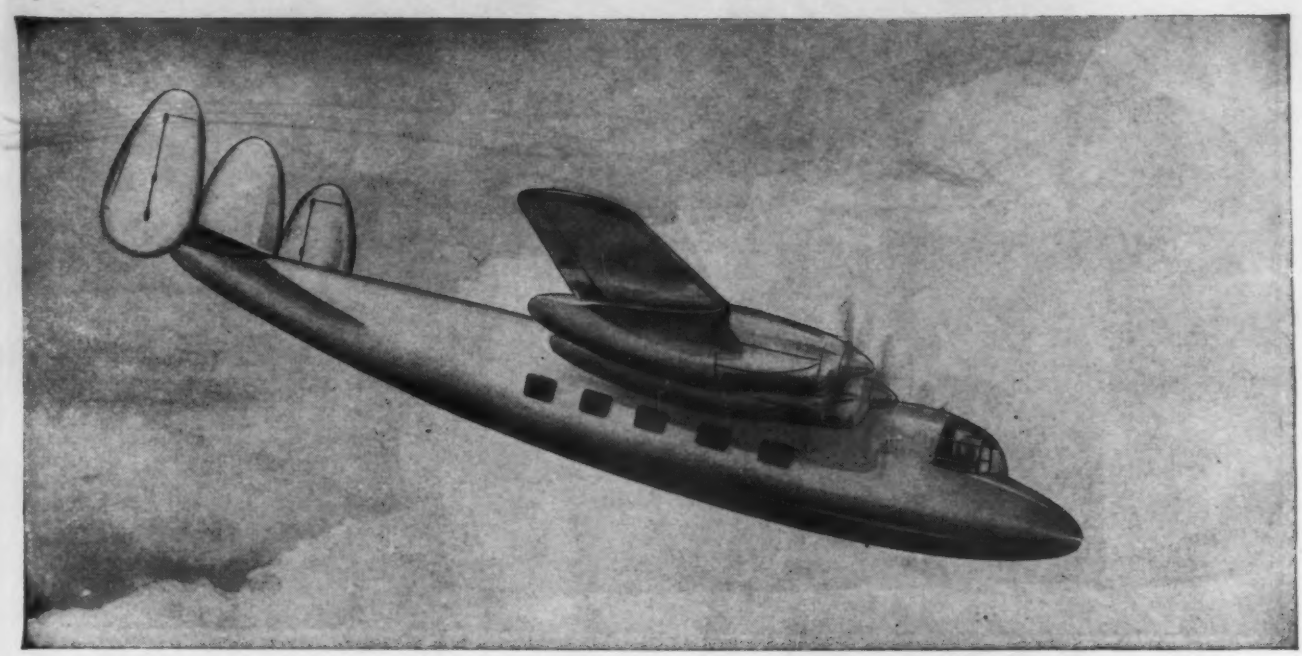
SOLAR MFG. CORP., 285 Madison Ave., New York 17, N. Y. Type LB etched-foil capacitors are now available in values from 8 microfarads



at 150 working volts d-c to 200 microfarads at 1.5 working volts d-c in containers measuring ⅜ by 1⅛ inches. In larger cases, ⅝ by 1⅝ inches the capacitances are 12 and 300 microfarads at the same voltages.

## Light Integrator (20)

SIDWARD MFG. CO., 261 Broadway, New York 7, N. Y. The Tim-O-Lux is a device for automatically integrating light and the length of time



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- Radio Quiet
- Single-piece Inserts
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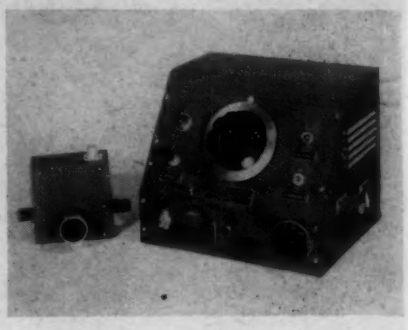
- High Arc Resistance
- Easy Assembly and Disassembly
- Low Electrical Resistance

SCINTILLA MAGNETO DIVISION of SIDNEY, NEW YORK — Bendix AVIATION CORPORATION

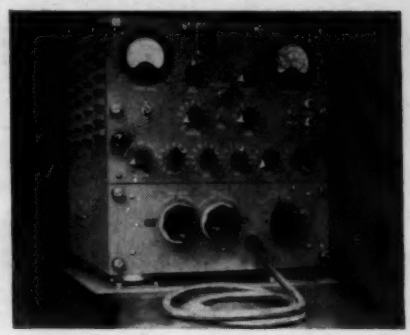


supplied for developing photographic emulsions. Fluctuations in light intensity are compensated in the instrument by additional exposure time so that once a satisfactory print has been obtained it is only necessary to leave the controls set for a complete run of prints from that negative.

## UHF Signal Generator (21)

HASTINGS SALES ENGINEERING CO., 532 Commonwealth Ave., Boston 15, Mass. The General Communication Co. model P142 uhf signal generator



is designed to furnish an r-f signal for calibration and alignment of receivers or for general laboratory work in the range from 1,200 to 4,000 mc. Unmodulated, pulse-modulated, or frequency-modulated signals can be selected at will. The oscillator is a velocity-variation reflex type using an adjustable cavity.

## Heavy-Duty Rectifier (22)

ELECTRONIC RECTIFIER Inc., 737 N. East St., Indianapolis, Ind. Ability to operate over a temperature range from minus 40 to 284 F, and light weight are the outstanding features of the new heavy duty magnesium-copper sulphide Lektron rectifier. Chief weight-saving feature is extension of the magnesium rectify-

*The Finest Cored Solder in the World*

# ENCORE!

**Ersin Multicore Solder was the first solder in the world to be made with THREE cores—and it is the *only* solder in the world made with extra-active non-corrosive ERSIN FLUX. No other solder offers you the same advantages of speed, efficiency, and economy per joint.**

### THE ADVANTAGES OF ERSIN FLUX

Ersin Flux, contained in the three cores of Multicore Solder, is a high grade rosin, subjected to a complex chemical process which increases its fluxing action without impairing the well-known non-corrosive properties of the original rosin.

### THE ADVANTAGES OF THREE CORES

The three core construction of Multicore gives High Speed precision production. Thinner solder walls provide extra rapid melting. Flux continuity eliminates waste of solder lengths without flux.

### THE ADVANTAGES OF QUALITY

Only the purest tin and lead are used in the manufacture of Ersin Multicore Solder. Multicore is made as standard in gauges between 10 and 22 S.W.G. (128 to 028 in. 3.251 to .711 mm.) and in five standard antimony-free alloys. Other alloys and gauges can be supplied to special order.

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# THREE CORE

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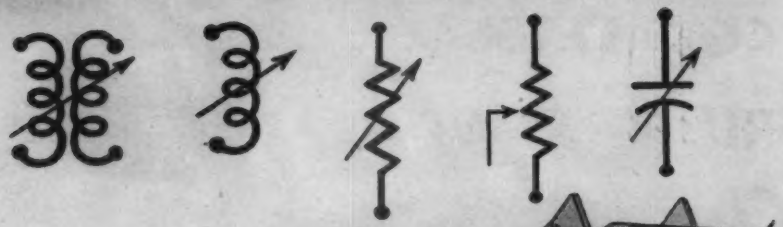
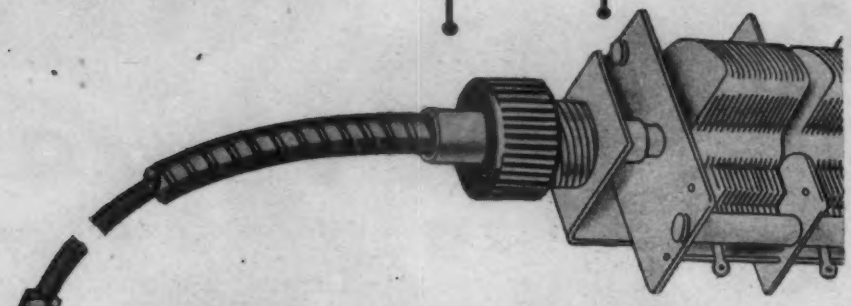
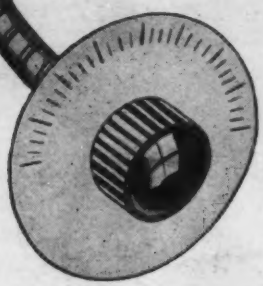
Enquiries regarding other territories to
MULTICORE SOLDERS LTD., Mellier House, Albemarle Street, London, W.1, England
Tel.: REGent 1411. Cables: Dustrikon, Piccy, London

**WHEN YOU SEE THESE SYMBOLS..**





**THINK OF S.S.WHITE FLEXIBLE SHAFTS**



The arrow identifies these symbols as variable elements. And where there are variable elements, it pays to think of S. S. White flexible shafts. As one well-known engineer puts it—

"In electronic equipment variable elements must be strategically located for premium electrical performance. In most cases the resultant mechanical placements of these elements do not readily adapt themselves to a symmetrical front panel placement of control knobs. S.S.White flexible control shafts, as couplings between the elements and their control dials, allow us complete freedom in our mechanical and electrical design."

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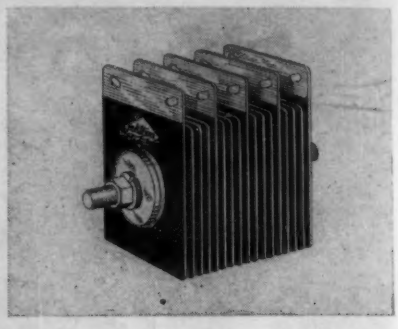
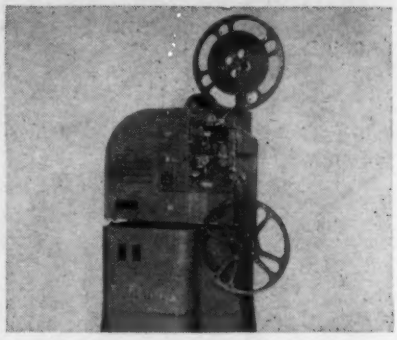


ing plates beyond the core dimensions of the rectifier to serve as heat radiating fins.

### Projector for Television Transmitters (23)

RADIO CORP. OF AMERICA, Camden, N. J. A new 16-mm television film projector type TP-16A is a modified sound motion picture projector adapted to project onto the mosaic of a television camera pickup tube as a means of programming television broadcast stations. The scanning sequence of ordinary film has been modified in the machine by the



introduction of elliptical gears so that the film motion is effectively synchronized with standard television signals. Radio-frequency voltage is used on the exciter lamp filament of the sound section and a stabilizer is provided to insure sound reproduction at virtually the originally recorded pitch.

### Multitester (24)

RADIO CITY PRODUCTS CO., Inc., 127 West 26th St., New York 1, N. Y. The model 462 multitester has a d-c sensitivity of 20,000 ohms per volt, uses a germanium crystal rectifier, and employs individual unit cells for the ohmmeter. The d-c ranges are 2.5 to 5,000 volts; a-c, 2.5 to 5,000 volts; 0.1 to 500 milliamperes

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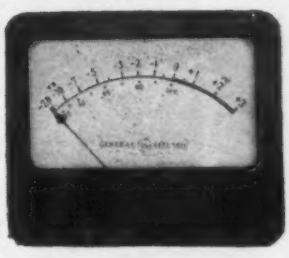

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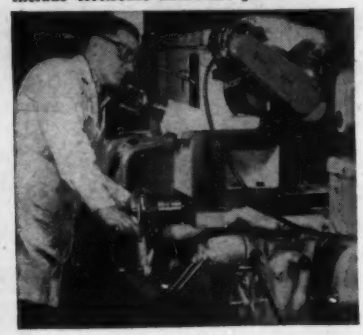

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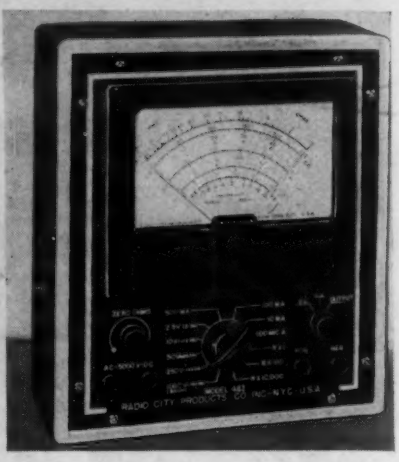
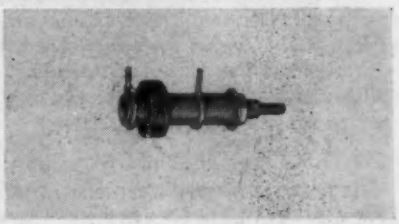


d-c; up to 100 microamperes and 20 megohms.

## Midget Inductors (25)

CAMBRIDGE THERMIONIC Corp., 445 Concord Ave., Cambridge 38, Mass. Type LSM midget inductors are



only $\frac{7}{8}$ inch high. Slug tuned, they can be used for filters, wave traps, or other inductive circuit elements.

## Audio Voltmeter (26)

FREED TRANSFORMER Co., Inc., 72 Spring St., New York 12, N. Y. The new type 1060 vacuum-tube voltmeter can be used at audio and ultrasonic frequencies as well as for a null detector in d-c bridge measurements. Input impedance is 50 megohms shunted by 15 micro-

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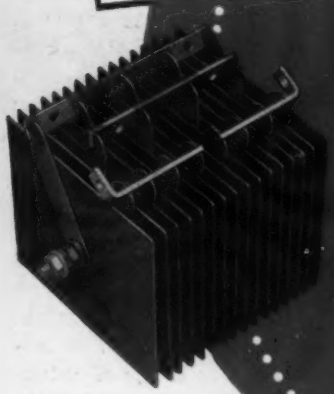

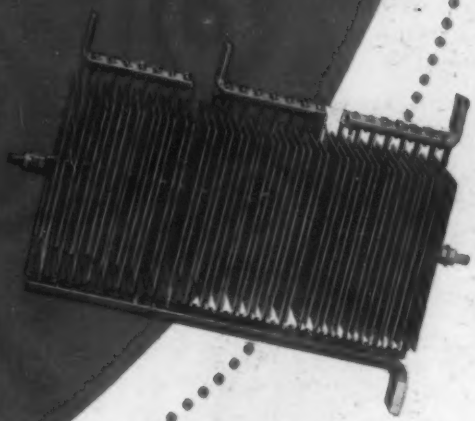

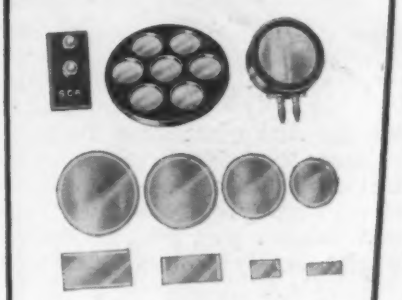

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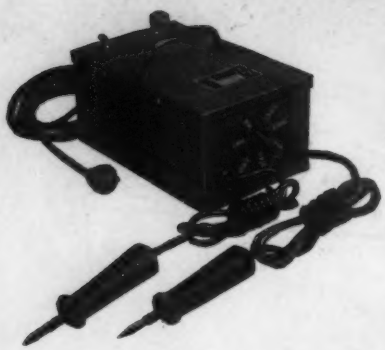
### ACME BREAKDOWN TESTER



An entirely new kind of testing unit that provides for actual checking of circuits at approved standard testing voltages and in addition indicates grounds, shorts or opens. 100% leakage type transformer limits current under short circuit conditions, thereby preventing needless destruction to materials at point of breakdown.

Instead of simply indicating the resistance value of the insulation, which serves no practical purpose, the Acme Insulation Tester permits the application of high voltages to positively prove the safety qualifications of the electrical device or apparatus under test. The Acme Insulation Breakdown Tester may be adjusted to supply voltages of double the rated voltage plus 1000 in accordance with Underwriters' Laboratories testing recommendations.

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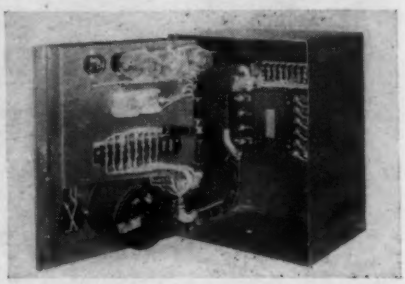
TRANSFORMERS




microfarads. Operating from 117-volt lines, the voltmeter has a frequency range from 10 cycles to 500,000 cycles, with a maximum variation not exceeding 0.5 db. Voltage ranges spread between 0.001 and 100 volts in five steps.

### Variable Speed Control (27)

WELTRONIC Co., 19500 West Eight Mile Road, Detroit 19, Mich. The series MCVAI is a variable speed control for 230-volt d-c motors from a 230-volt a-c power source. The

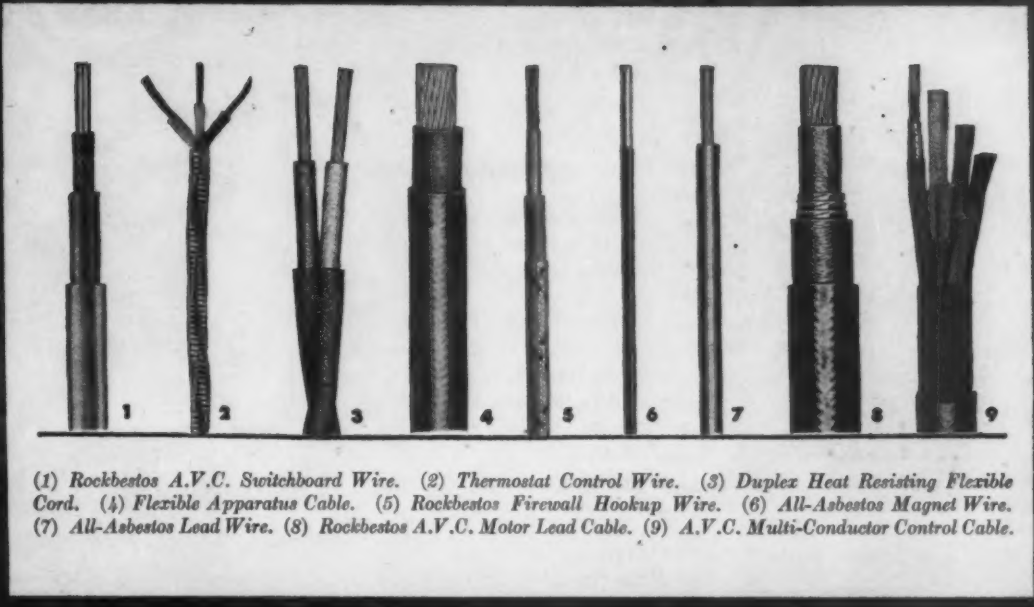


unit can be used on any shunt-wound d-c motor up to and including ½-hp rating. Remote forward, reverse, and stop pushbutton controls can be provided as well as a remote speed control. Dynamic braking of the machine is included.

### X-Ray Counter (28)

WESTINGHOUSE ELECTRIC Corp., 306 Fourth Ave., Box 1017, Pittsburgh 30, Pa. The new counter that records x-rays at a speed of 1 microsecond over a wide range of intensities consists of a photomultiplier tube wrapped in a sheet of fluorescent screen covered with black pa-

# You're Looking at 9 Wire-Failure PROBLEM SOLVERS

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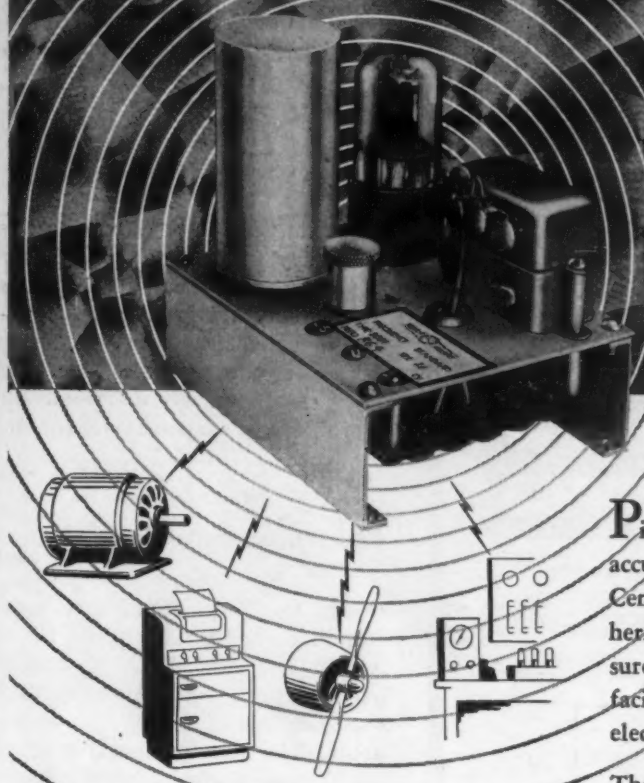
# PICK A NUMBER

ANY FREQUENCY FROM 40 TO 1,000



Pictured here is a tuning-fork frequency standard with accuracy guaranteed to one part per million per degree Centigrade. The fork is temperature-compensated and hermetically sealed against variations of barometric pressure. This standard, when combined with basic equipment, facilitates accurate speed and time control by mechanical, electrical, acoustical or optical means.

The unit is available separately or in conjunction with complete timing instruments. Our engineers are ready to cooperate on any problem.

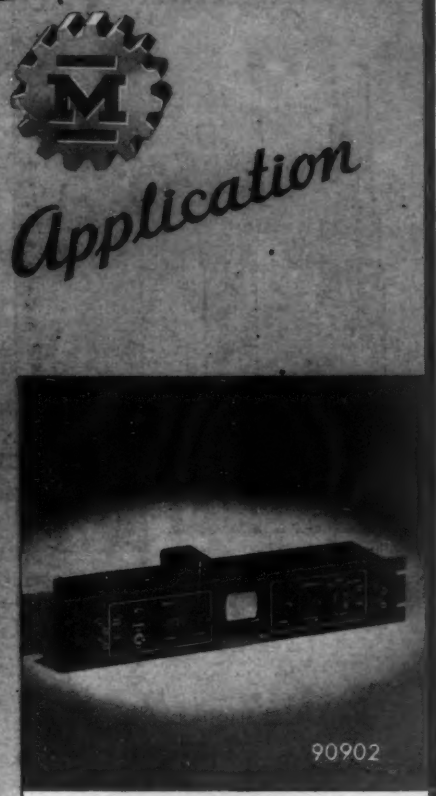
MOTORS · FACSIMILE · AIRCRAFT · LABORATORIES

American Time Products Inc

580 Fifth Avenue

OF THE WESTERN ELECTRIC COMPANY

Designed for




**90900 Series**
***Cathode Ray Oscilloscopes***

The No. 90902 and No. 90903 Rack Panel (3½") Oscilloscopes, for two and three inch tubes, respectively, are inexpensive *basic units* comprising power supply, brilliancy and centering controls, safety features, magnetic shielding, switches, etc. As a transmitter monitor, no additional equipment or accessories are required. The well-known trapezoidal monitoring patterns are secured by feeding modulated carrier voltage from a pick up loop directly to vertical plates of the cathode ray tube and audio modulating voltage to horizontal plates. By the addition of such units as sweeps, pulse generators, amplifiers, servo sweeps, etc., all of which can be conveniently and neatly constructed on companion rack panels, the original basic 'scope unit may be expanded to serve any conceivable application.

Application

**JAMES MILLEN MFG. CO., INC.**

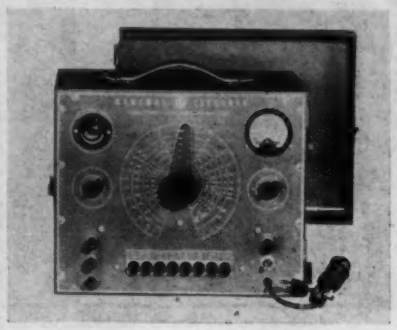
MAIN OFFICE AND FACTORY
MALDEN
MASSACHUSETTS




per. Visible light is blocked by the paper but the tube detects and amplifies the fluorescent light that appears when an x-ray strikes the screen.

### Capacitor-Resistor Bridge (29)

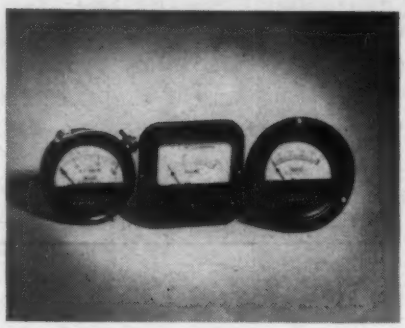
GENERAL ELECTRIC CO., Syracuse, N. Y. The type YCW-1 portable capacitor-resistor bridge will measure capacitance from 0.000005 to 200 microfarads in three ranges



and resistance from 5 ohms to 20 megohms in two ranges. Insulation resistance, leakage current, and power factor are also indicated.

### Panel Meters (30)

SHURITE METERS, 61 Hamilton St., New Haven 8, Conn. A complete line of a-c and d-c meters of the 2- and 2½-inch types are available in



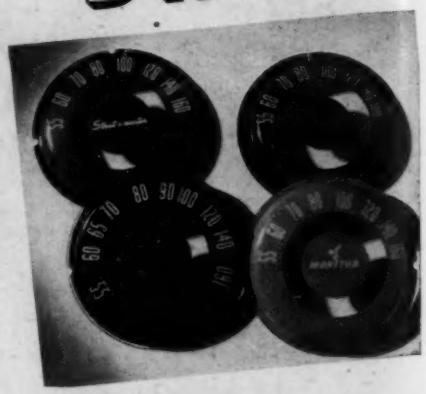
round or rectangular cases. All d-c meters are polarized-vane and solenoid type, while the a-c meters are double-vane repulsion type. They are further described in Bulletin F-64.

### Antistatic Tire Powder (31)

UNITED STATES RUBBER CO., Rockefeller Center, New York, N. Y. A powder that can be blown into auto-


**precision-fabricated**

# PLASTIC DIALS



**QUALITY and SERVICE AT A PRICE THAT'S RIGHT**

You can't go wrong when you depend on Sillcocks-Miller for plastic dials. These experienced engineers are recognized throughout the industry for their ability to fabricate plastic materials to close tolerances. The combination of this skill and complete production facilities provides a dependable source for the quality and service you want — at a price that's right.

Write for illustrated booklet or phone South Orange 2-6171 for quick action.

**THE SILLCOCKS-MILLER CO.**

10 West Parker Avenue, Maplewood, N. J.
Mailing Address: South Orange, N. J.

SPECIALISTS IN HIGH QUALITY, PRECISION-MADE PLASTICS FABRICATED FOR COMMERCIAL, TECHNICAL AND INDUSTRIAL REQUIREMENTS.

National

EST. 1914

# THE NATIONAL EMBLEM ON PARTS IS YOUR GUARANTEE OF QUALITY

For over 25 years, hams, engineers and radio technicians have agreed that National parts were thoroughly reliable in manufacture and performance.

That reputation is your guarantee of quality when ordering National parts for new equipment.

If you need parts that will fit as they're supposed to, that will give you long hard service, then National's your best bet — as any radio veteran can tell you.

Send today for your copy of the new 1947 National catalog, containing over 600 parts.

**Type AR-16 (Air-Spaced) Exciter Coils and Forms**

These air-spaced coils are suitable for use in stages where the plate input does not exceed 50 watts and are available for the 6, 10, 20, 40 and 80 meter bands. All have separate link coupling coils and all include the PB-16 plug, which fits the XB-16 Socket.

AR-16 Coils, End Link, Center Link or Swinging Link. Net price.....$1.15 (Include PB-16 Plug)

PB-16, Plug in Base Only.....Net price....$ .27

XB-16, Plug-in Socket Only.....Net price....$ .33

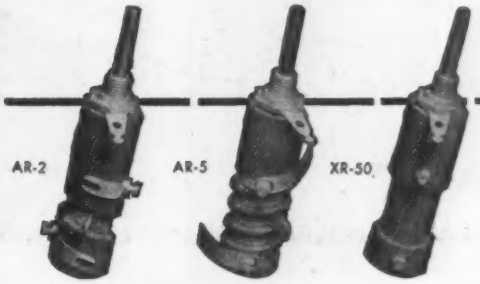
The HRT is a new plastic tuning knob with a chrome plated appearance circle. The HRT knob fits a ¼" diameter shaft and is 2⅛" in diameter. Available in Black or Gray.

HRT Knob....Net price....$ .75

**National Company, Inc.**
**Malden, Mass.**

Please write to Department 10 National Company, for further information.

The HRS Knobs are a new series of plastic knobs with a 1⅜" diameter chrome-plated skirt. They all fit ¼" diameter shafts. Three types are available in Black or Gray.




The AR-2 and AR-5 coils are high Q permeability tuned RF coils. The AR-2 coil tunes from 75 mc to 220 mc and the AR-5 coil tunes from 37 mc to 110 mc with suitable capacitors.

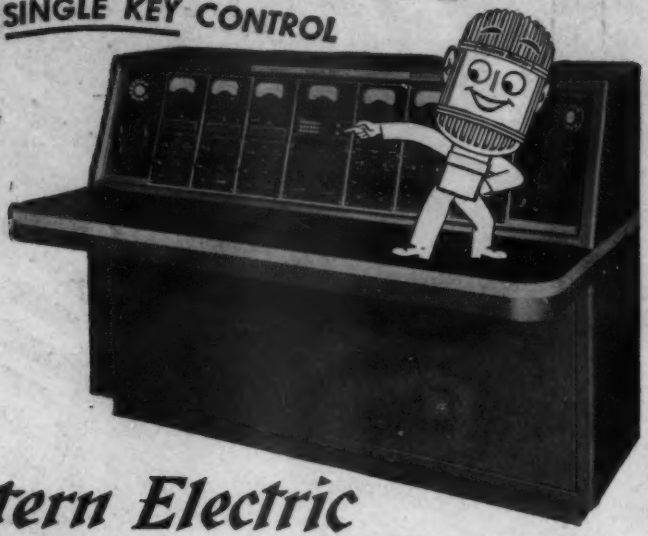
XR-50 coil forms may be wound as desired to provide a permeability tuned coil. The form winding length is 11/16" and the form winding diameter is ½". The iron slug is ⅜" diameter by ½" long.

HRS-1 Knob....ON-OFF through 30° rotation.....Net price.....$ .51
HRS-2 Knob....5-0-5 through 180° rotation.....Net price.....$ .51
HRS-3 Knob....0-10 through 300° rotation.....Net price.....$ .51

AR-2 High Frequency Coil.....Net price.....$1.71
AR-5 High Frequency Coil.....Net price.....$1.46
XR-50.....Net price.....$1.01

**MAKERS OF LIFETIME RADIO EQUIPMENT**

BROADCAST PROGRAM SWITCHING IS A CINCH
...WITH SINGLE KEY CONTROL

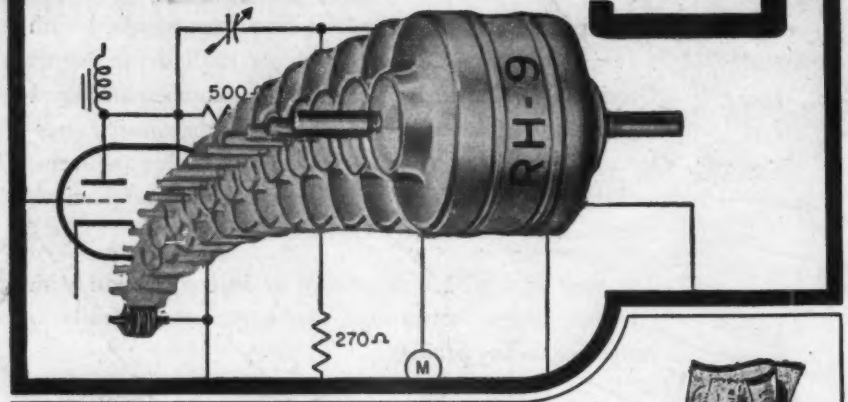


Western Electric
PROGRAM DISPATCHING SYSTEM

This new Relay Type Program Dispatching System reduces your most complicated radio broadcast switching operations to the movement of *one* key. It speeds up switching in serving several destinations with rapidly interchanged studio, line and transcribed programs, auditions and announcements. For full details on its many operating advantages, write Graybar Electric Co., 420 Lexington Ave., New York 17, N. Y., or...

ASK YOUR LOCAL Graybar
BROADCAST REPRESENTATIVE

RH-9




THE LATEST IN VHF HARMONIC MODE CRYSTAL UNITS

With RH-9 in a simple one tube oscillator circuit output X-tal frequencies from 12 to 75 mc, while operating in the 3rd, 5th, or 7th mechanical mode, can be generated. These frequencies can be multiplied to higher frequencies as desired.

- .005% maximum frequency drift from —55°c to +90°c
- Capacity between pins approximately 1 mmfds
- Shock and vibration tested (Ideal for mobile equipment)
- For transmitting, receiving, and filtering circuits
- For FM and TV
- Higher frequencies on special order

For Specifications of Crystal Unit RH-9 write for Catalog RHC-2

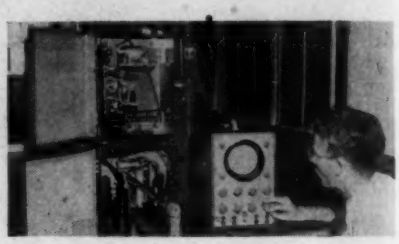
R H
REEVES-HOFFMAN
CORPORATION
SALES OFFICE 215 EAST 91 STREET, NEW YORK 28, N. Y.
PLANT: 321 CHERRY STREET, CARLISLE, PA.



mobile inner tubes reduces one particular type of static encountered in automobile radio installations. An air hose and specially designed container are used to inject a small amount of the powder into a deflated tube.

## Cathode-Ray Oscilloscope (32)

RADIO CORP. OF AMERICA, Camden, N. J. The type WO-60C is a general-purpose oscilloscope built especially for use in industrial applications. It will handle voltages as high as



850 volts peak to peak and its low-frequency response reaches 0.5 cycles. Upper limit is 300,000 cycles. Three tubes are furnished for general applications, low-frequency work, or photographic recording. They can be quickly and easily inserted for the specific job of the moment.

## Electronic Automatic Sorter (33)

DOALL CO., 254 North Laurel Ave., Des Plaines, Ill. The model DS-20 packaged selector for mechanical parts consists of three units—gage head, master control, and segregator. The selector is adjusted by use of gage blocks. Lights indicate the go-no-go tolerances at the same time that a meter indicates exact dimensional variations from the standard. Attachments for counting numbers of pieces or making the

FOUND THESE

Here are two rare bargains for the engineer who needs them . . . and at a bargain! But that's the way Harvey operates . . . all the standard merchandise in stock . . . specials when they are real buys, or hard-to-get.

2.5 KW TRANSFORMER

Step-up or step-down power transformer. Type CRP-301223, made by Raytheon Mfg. Co. From 220/440 v. to 115 v., or from 115 v. to 220/440 v. Rated 2.5 kw. Measures 10½ inches square by 11½ inches high. Completely louvred and well insulated and shielded steel case with mounting brackets. Weighs app. 65 lbs. Harvey Special Price $49.50

CONSTANT VOLTAGE TRANSFORMER

Here's the item everyone has been waiting for . . . a constant voltage transformer very conservatively rated at 0.82 kw. Primary voltage 92-138 v., secondary voltage 115 ½ of 1%. Shipping weight app. 130 lbs. A rare bargain at $135.00

• • • • • •

Among the many stock items which Harvey always has in stock are test instruments and equipment. This sample is typical:

GE Electronic Switch, Type YE-9. This instrument was designed for special electrical studies of wave-form, phase, frequency relationship, etc. It will show the simultaneous observation, for comparison, of two or more independent signals on the screen of a cathode-tube oscillascope. $59.50

*Note: All prices are Net, F.O.B. NYC and are subject to change without notice.*

Telephone: LO. 3-1800

HARVEY RADIO COMPANY INC.

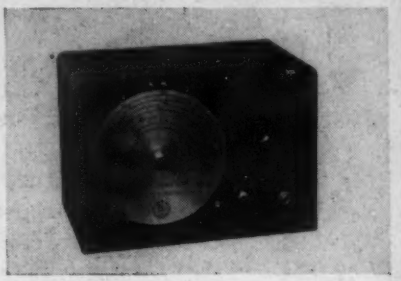
103 West 43rd St., New York 18, N. Y.




equipment operable by a sightless person can be supplied.

## Amateur Frequency Meter (34)

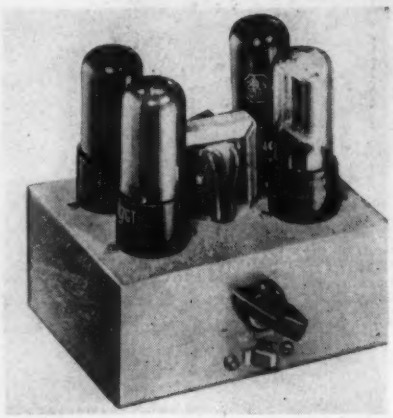
BROWNING LABORATORIES, INC., Winchester, Mass. The model MJ-9 frequency meter provides a means for checking the frequencies of f-m



or a-m transmitters operating in the amateur bands from 3.5 to 148 mc. A 500-kc crystal oscillator is used as a reference standard and the overall accuracy of the unit is 0.05 percent at all frequencies.

## Phonograph Amplifier (35)

ALLIED RADIO CORP., 833 West Jackson Blvd., Chicago 7, Ill. The Knight 4-watt amplifier can be driven by any high-impedance crys-

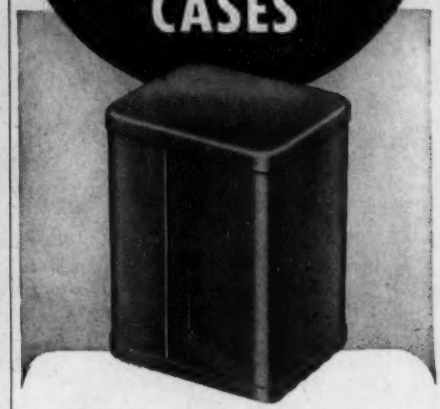


tal pickup and will satisfactorily operate a 10-inch speaker. It is physically small so that it can be fitted into a cabinet designed for turntable and speaker combinations.

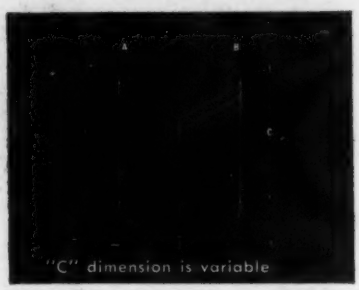
## Double Winding Relay (36)

STEVENS-ARNOLD CO., 22 Elkins St., South Boston, Mass. The type 162 relay has double windings, one of


OLYMPIC STANDARD TRANSFORMER CASES



Now available in quantity, OLYMPIC standardized transformer cases are specifically designed to meet all normal requirements where standard cases are used. Construction is rigid, with rounded corners, and tight-fitting covers top and bottom. OLYMPIC standard transformer cases can be furnished with pierced covers, studs, brackets or channels. Inquiries are invited—write for illustrated bulletin—no obligation.




"C" dimension is variable

| CORE | CASE | A | B | C |
|---|---|---|---|---|
| E1-21 | 1 | 1¾" | 1⅝" | 2⁹⁄₁₆" |
| E1-625 | 2 | 1⅞" | 1⅞" | 2¹¹⁄₁₆" |
| E1-75 | 3 | 2⅛" | 2⅛" | 2¹³⁄₁₆" |
| E1-11 | 4 | 2⅜" | 2½" | 3¹⁄₃₂" |
| E1-12 | 5 | 3" | 2⅝" | 3²³⁄₃₂" |
| E1-3A | 6 | 3¼" | 3" | 3¹³⁄₃₂" |
| E1-112 | 7 | 3⅜" | 3¼" | 4³⁄₃₂" |
| E1-125 | 8 | 3¾" | 3½" | 4¹³⁄₃₂" |
| E1-137 | 9 | 3⅞" | 3⅞" | 4²³⁄₃₂" |
| E1-13 | 10 | 4⅜" | 4¼" | 5¹³⁄₃₂" |
| E1-151 | 11 | 5" | 4⅝" | 5¹³⁄₃₂" |
| E1-36 | 12 | 5⅛" | 4⅝" | 6¹³⁄₃₂" |

CRAFTSMANSHIP JM IN METAL PARTS

OLYMPIC TOOL & MFG. CO., INC.

39 CHAMBERS ST. NEW YORK 7, N. Y.

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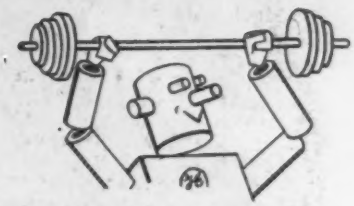
# For HIGH DIELECTRIC STRENGTH...

● When you specify General Electric mycalex for your designs, small as well as large electric parts can be *completely* insulated. This gray, stone-hard compound of glass and mica is recommended for its high dielectric strength—low loss factor—toughness—heat resistance—chemical and dimensional stability.

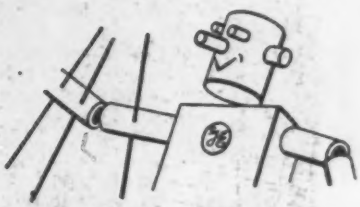
G-E mycalex is available in the shapes and quantities you need. It can be ordered in standard rods and sheets, or it can be molded or fabricated to your specifications. Samples will be supplied to you on request.

You can test this unique insulating material in your own plant by having G-E mycalex specialists fabricate sample parts from your designs. After testing, your designs can be converted to the speediest, most economical molding processes. For more details, send for a free copy of General Electric's booklet, "G-E MYCALEX." Just write to Section S-20, Plastics Division, Chemical Department, General Electric Company, 1 Plastics Avenue, Pittsfield, Massachusetts.

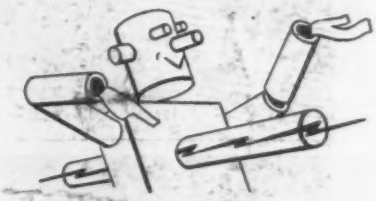
## Plus these 5 Insulation Advantages . . .



● HIGH MECHANICAL STRENGTH



● FIRM BOND TO METAL INSERTS



● LOW LOSS FACTOR

● HIGH ARC RESISTANCE

● HIGH HEAT RESISTANCE

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Foil Dials
Tablet & Ticket Metal Foil Radio and Instrument Dials are fabricated from special dial board with foil laminated to both sides to eliminate warping — prevent moisture absorption. Processed in colors on either silver, gold or copper shades of foil, unusually rich combinations are readily obtainable at unbelievably low costs. Then, too, the exclusive T & T Perfect-O-Cut Dial Process not only produces a third dimensional effect by high embossing but also assures absolute register because cutting die is an integral part of printing and embossing plate.
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PRECISION ATTENUATORS
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TYPE
850-A 850-B
The units illustrated represent a complete redesign of our older precision attenuators for laboratory standards. Flat for all frequencies in the audio range. Reasonably flat to 200 k.c. up to 70 db.
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TECH LABORATORIES, INC.
Manufacturers of Precision Electrical Resistance Instruments
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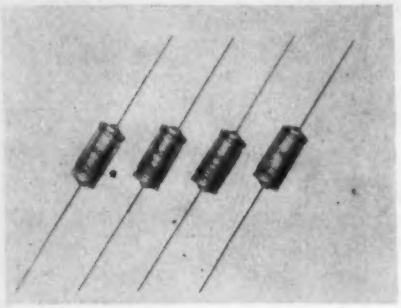
which is used for operation and the other as a hold-in coil. It is made in one size with single-pole, double-throw contacts for use with resistive or capacitive loads. Catalog 214 gives complete information on how to use this device for photoflash and similar service.

### Television Capacitors (37)

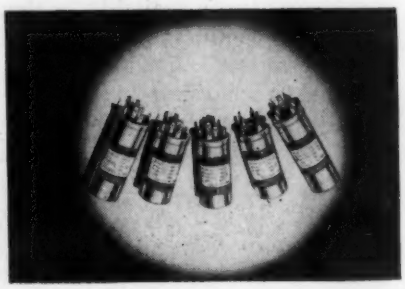
CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J. The type TMC series of capacitors with capacitance range from 0.005 to 0.05 microfarad in d-c voltage ratings



from 2,000 to 5,000 volts has been particularly designed to meet the requirements of television equipment manufacturers. The units are tubular metal-can types with end leads.

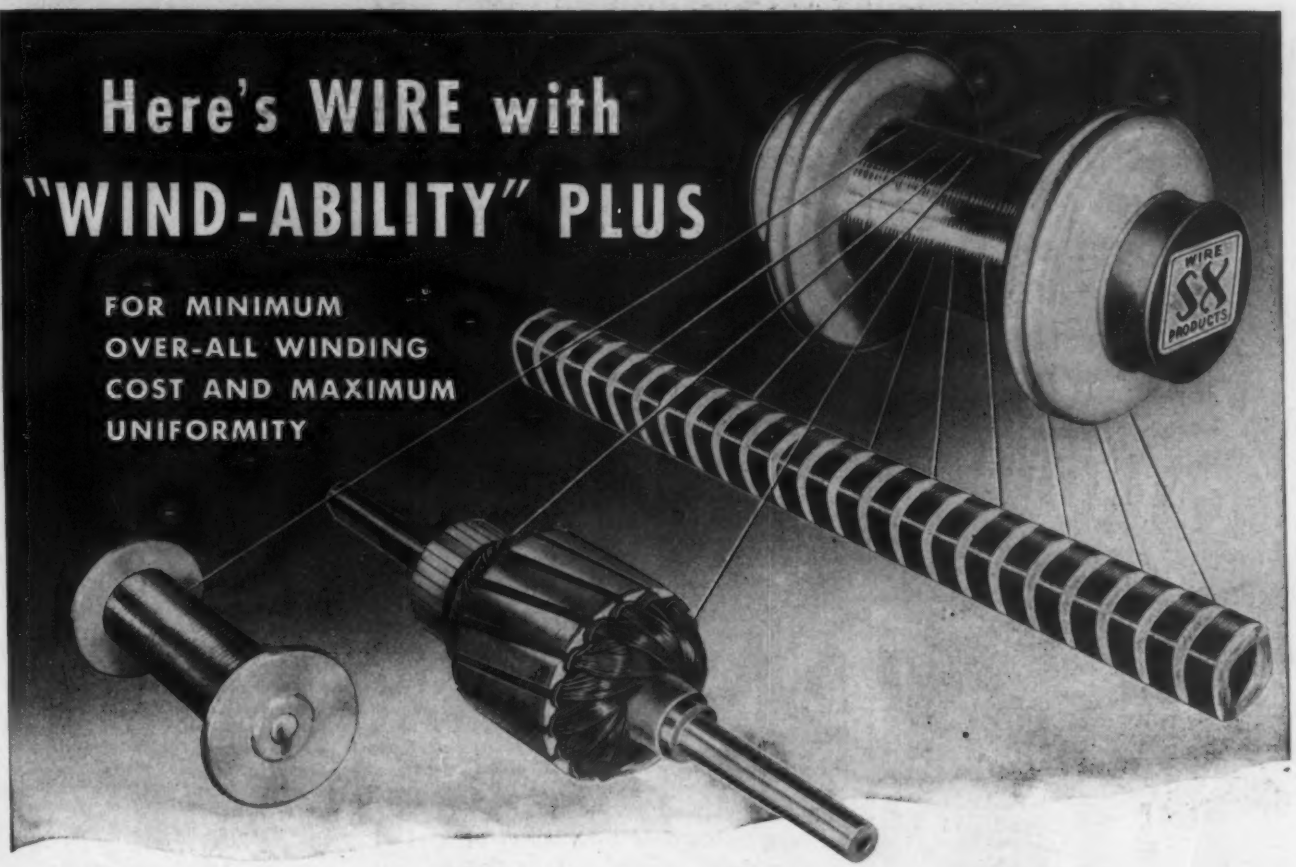
### High-Frequency Capacitors (38)

CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J. The type UP electrolytic capacitors are characterized by their ability to operate



# Here's WIRE with "WIND-ABILITY" PLUS

FOR MINIMUM OVER-ALL WINDING COST AND MAXIMUM UNIFORMITY




HIGH SPEED winding—whether bobbin, random or gang—subjects magnet wire to punishing treatment. Insulating film must be tough, yet pliable. Copper must have the proper degree of anneal. The spool-to-spool uniformity must be right.

Essex Extra-Test Magnet Wire has earned an unexcelled reputation in the most exacting applications. It helps insure coils of uniform size and resistance value — maximum turns in available space — freedom from broken wires, pile-ups, crossed turns, runbacks, spaced turns, and frequent tension adjustments. When you specify Essex Extra-Test Magnet Wire you can be *sure*.

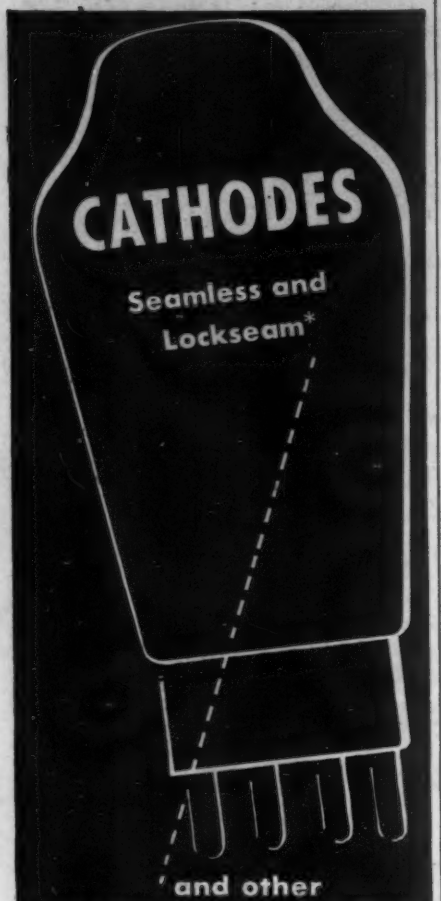
WIRE SX PRODUCTS

Plants: Fort Wayne, Indiana; Detroit, Michigan; Anaheim, California
Warehouses* and Sales Offices: *Atlanta, Ga.; *Boston, Mass.; *Chicago, Ill.; Cleveland, Ohio; Dallas, Texas; Dayton, Ohio; *Detroit, Michigan; Kansas City, Mo.; *Los Angeles, California; Milwaukee, Wisconsin; *Newark, N. J.; Philadelphia, Pa.; *St. Louis, Mo.; *San Francisco, California.

**ESSEX WIRE CORPORATION**
FORT WAYNE 6, INDIANA

Superior

RESEARCH, DEVELOPMENT AND LOW COST PRODUCTION OF




and other
"WITHIN THE ENVELOPE"
TUBULAR STRUCTURES
for all types of
ELECTRON TUBES
TO STANDARD SPECIFICATIONS OR SPECIAL DESIGN
*Produced under Superior patents

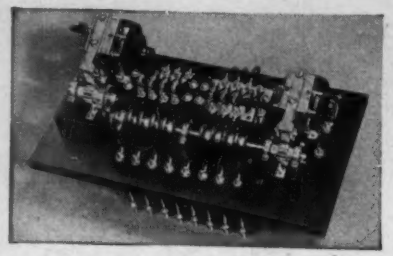
Superior
SUPERIOR TUBE COMPANY
ELECTRONICS DIVISION
2500 Germantown Ave.
NORRISTOWN, PA.



at high temperatures. An additional feature is the elimination of intercoupling between individual sections at radio frequencies. Dimensions of the regular type UP capacitors have not been exceeded.

### Multipole Sequence Relay (39)

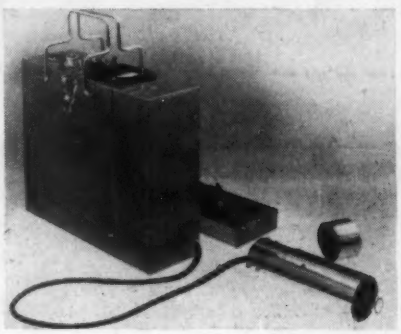
STRUTHERS-DUNN, INC., 146 No. 13th Street, Philadelphia 7, Pa. A new reversing, separate-circuit ratchet-operated multipole sequence relay known as type 96AFA, it is adaptable to numerous applications involving the addition and subtraction of loads, as in switching in or switching out individual units from



a bank of capacitors. It is a two-coil relay. One operating coil steps the cam shaft forward, a step at a time. Similarly, the second operating coil steps the shaft in the reverse direction. Mechanical stops limit the forward and reverse travel of the shaft. Standard ratchets supplied have 12 teeth. Thus a total of 12 contacts may be obtained in a sequence, with no more than 6 separate contacts between each pair of bearing supports. Operating coils are for a-c use only. Engineering data Section 4681 contains full details on this as well as other sequence relays.

### Radiation Detector (40)

NORTH AMERICAN PHILIPS CO., Inc., 100 East 42nd St., New York 17, N. Y. A new compact portable Geiger-counter radiation detector uses



Silicone News
DC

Gaskets of Silastic*
Seal High Vacuum Systems

COURTESY MINNEAPOLIS-HONEYWELL REGULATOR CO.

Silastic, the Dow Corning Silicone Rubber, is a unique kind of rubber-like material. It has special properties which enable it to give excellent service in many situations where organic rubbers fail rapidly. You can do things with Silastic which can't be done at all with organic rubbers. You can do many things better with Silastic than you can with conventional rubbers.

Consider the sealing of high vacuum systems, for example. Organic rubbers are used for this purpose, but they have to be "conditioned" by heat treating or leaching with solvents. Such treatment generally removes the volatile materials which would destroy the vacuum and contaminate the system—but it weakens the rubber and makes it less resilient.

Gaskets of Silastic, however, need no conditioning. No plasticizers of any kind and no organic rubbers are added to Silastic. It is cured at temperatures beyond the limits of most organic rubbers and is non-volatile even at high temperatures and under high vacuum. That's why Minneapolis-Honeywell Regulator Co. uses gaskets of Silastic to seal high vacuum systems in which lenses are coated with magnesium fluoride vaporized at high temperatures.

Silastic stays elastic in arctic cold or oven heat. It is inherently stable to extreme heat, cold, and weathering. Some stocks also have exceptional resistance to chemical attack. Silastic is, therefore, an ideal gasketing material for many industrial uses, including high vacuum equipment. Its usefulness as a gasketing material is described in leaflet No. N 13-2.

*TRADE MARK, DOW CORNING CORPORATION

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- Uses of Glassmikes for improved RF and Audio bypassing
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Many manufacturers find it advantageous to turn over their contact assembly problems to Wilco. From Wilco's accumulated experience, they obtain contact assemblies precisely conforming in size, shape and material to their individual requirements.

Wilco Contact Assemblies are fabricated by an organization of thoroughly skilled engineers and craftsmen, with a 33-year record of adapting electrical contacts and thermostatic bimetals to thousands of industrial and military applications. They embody—like *all* Wilco materials—the basic excellence for which Wilco has been famous since 1914.

Contact materials of maximum ductility, hardness, density, freedom from sticking, low metal transfer, high conductivity and arc-resistance . . . Thermostatic Bimetals meeting the most exacting standards for temperature indication, temperature control and temperature compensation . . . these are the advantages of Wilco contact assemblies.

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**NI-SPAN C***
New Constant Modulus Alloy

**SPECIAL MATERIALS**

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The International Nickel Co., Inc.

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*The superiority of a triode amplifier is most apparent in the final test . . . listening*

★TRIODE TUBES used throughout. 2—6B4G, 4—7A4, 2—7N7, 1—5U4G, 1—5Y3G.

★Three push-pull stages preceded by an inverter stage.

★Interstage transformer insures good push-pull balance.

★Flat within 1 db to 25 cycles at full power and to 4 cycles at reduced power.

★Flat within 0.2 db to 30,000 cycles.

★0.6% harmonic distortion and 0.2% intermodulation distortion at 5 watts.

★Rated power—30 watts at 2½% total distortion.

★AUTOMATIC BIAS CONTROL greatly increases undistorted power at moderate cost.

★Gain—55 to 120 db in various models.

★Bass and treble compensation—Two-stage tapped condenser-resistor networks.

★Input—3B, 150, 500/600 and 500,000 ohms. Output—1.5 to 30 ohms and 500 ohms.

★Power available for other units—250 volts, 0.090 A DC; 6.6 volts, 5 A.

★Fuses—Main power and 6B4G plate line.

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## Paramount PAPER TUBE CORP.

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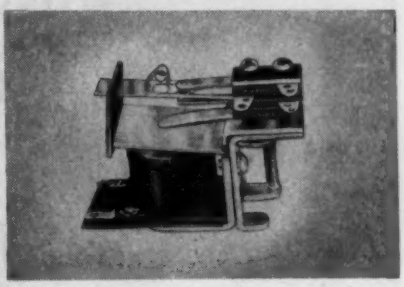
*Manufacturers of Paper Tubing for the Electrical Industry*




five tubes and can be carried in the hand or by a shoulder strap. Controls and indicators are located on a top panel so that adjustments and measurements can be made while the unit is being carried.

### Snap-Action Relay (41)

GUARDIAN ELECTRIC MFG. CO., Dept. SA, 1625 West Walnut St., Chicago 12, Ill. The series 100 relay with



snap-action contacts is suitable for such use as motor starting in which fast make and break are desirable.

### Resistor Kit (42)

INTERNATIONAL RESISTANCE CO., 401 North Broad St., Philadelphia 8, Pa. A new basic kit of resistors suited for engineering and development laboratories, broadcast sta-

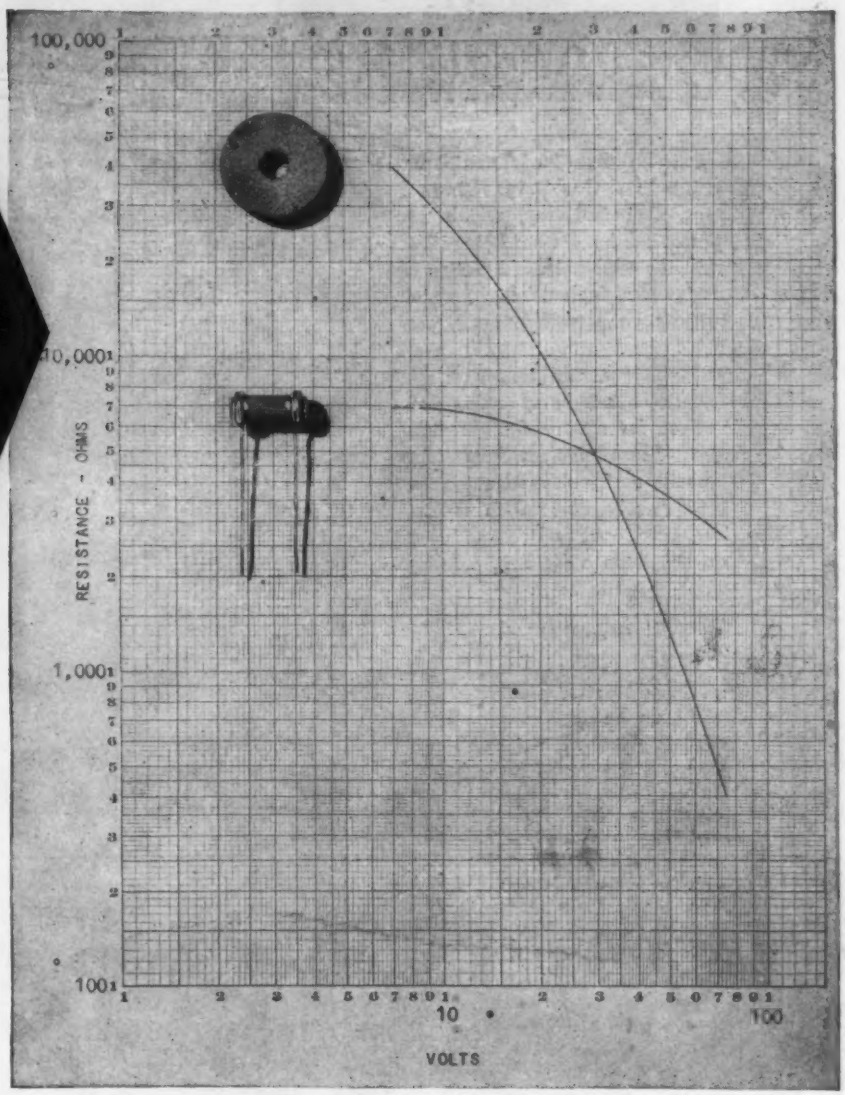
tions, schools, and colleges contains 471 basic resistors and 6 bands for adjustable types. They are all packed in a metal cabinet.

### Resistance Limit Bridge (43)

HERBACH AND RADEMAN CO., 517 Ludlow St., Philadelphia 6, Pa. The RLB110M electronic resistance limit bridge has been designed for the rapid production testing of resistors in the tolerance ranges of plus and minus 5, 10, 15, or 20 percent. It is essentially a d-c Wheatstone bridge followed by a two-stage direct coupled d-c vacuum tube

# HOW Resistance-Voltage Characteristics are altered by Resistor Design

**TYPE BNR "GLOBAR" VOLTAGE SENSITIVE RESISTORS**




Here are negative resistance-voltage curves plotted for two GLOBAR type BNR Resistors. Both resistors are voltage sensitive. However, the two curves coincide at one point only, namely, 30 volts. But, of more importance, observe how the difference in resistor design drastically alters its characteristics. Note the effect a change in the shape of the resistor has on the slope of its resistance-voltage curve. Fundamentally, this change in characteristics is accomplished by altering the specific resistance of the resistor.

Graphically presented here, this variance in characteristics—caused by resistor design points up an important factor in specifying and ordering GLOBAR resistors to meet exact needs of specific applications. It is a good reason why GLOBAR resistors are not carried in stock, but are quickly made to your requirements.

To save time and trouble in producing for you voltage sensitive resistors that will do the job for which they are intended, we ask only that you furnish a few simple facts. Briefly tabulated, this neccessary information is:

1 Type of apparatus in which the resistors are to be used.
2 Method of mounting and space limitations.
3 Normal operating voltage and peak voltage if available.
4 Resistance and inductance of the circuit if available.
5 Ohmic resistance of the resistor and allowable plus and minus tolerance.
6 Maximum voltage applied continuously or intermittently.
7 Duration of load and elapse of time between its application.

For your engineering tests, we can furnish samples in a hurry. For any information that may be helpful in working out your resistor problems, feel free to call on us. The Carborundum Company, Globar Division, Niagara Falls, N. Y.

# GLOBAR Ceramic Resistors BY CARBORUNDUM

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BRADLEY

PHOTO ELECTRIC CELLS

SIMPLIFY PHOTO-ELECTRIC APPARATUS

Luxtron* photocells convert light directly into electrical energy. No external source of voltage is required. Meters and relays can be operated directly from Bradley Luxtron photocells, improving control over manufacturing operations, reducing your costs. They meet the most exacting requirements. Advanced manufacturing techniques make light-actuated Bradley cells the choice all over the world.

Besides the housed model shown with its plug-in contacts, Bradley also offers tube socket, nut-and-bolt types and pigtail contact mountings. In addition, Luxtron unmounted cells are available in many different sizes and shapes.

*T. M. REG. U. S. PAT. OFF.

Illustrated literature, available on request, shows more models of Bradley photocells, plus a line of copper oxide and selenium rectifiers. Write for "The Bradley Line."

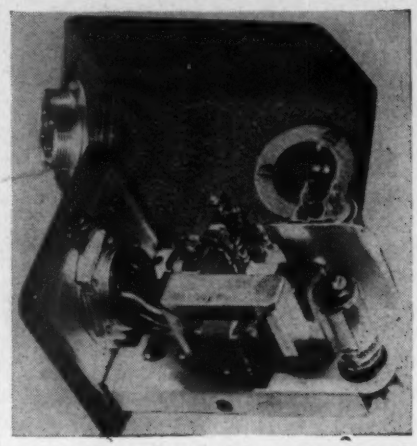
BRADLEY LABORATORIES, INC.

82 Meadow St. New Haven 10, Conn

voltmeter circuit arranged so that the resistance deviation from the desired value is directly indicated on a meter. A battery source of low voltage has been used to insure accurate measurements as low as 1 ohm without excessive power dissipation.

## Photo Relay (44)

SPECIAL PRODUCTS CO., Silver Springs, Md. A phototube relay intended for industrial use has plug

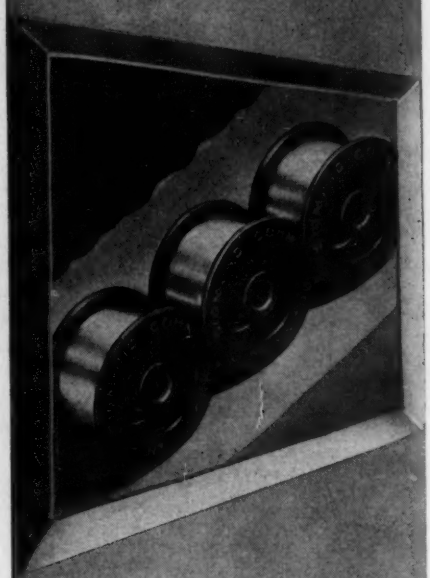


connections for quick removal and replacement with an identical unit. Speed of operation of the equipment is 1/20 second, with ¼ second for release. The output circuit contains a relay that will handle a 5-ampere noninductive load.

## Automatic Rheostat (45)

ELECTRIC REGULATOR CORP., 1915 Park Ave., New York 35, N. Y. The Regohm is a new automatic rheostat that can be used as a variable circuit element for a regulated rectifier, saturable reactor power amplifier or similar device. It consists of a solenoid that gradually opens up to ten contact fingers sequentially as current through the

MICRODIMENSIONAL WIRE & RIBBON FOR VACUUM TUBES



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Model 1600—115 volt Candelabra lamp.
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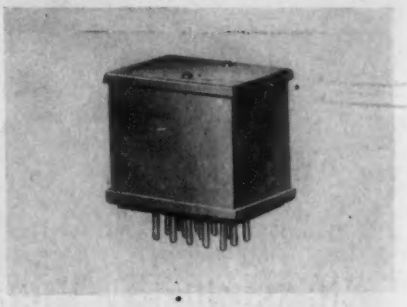
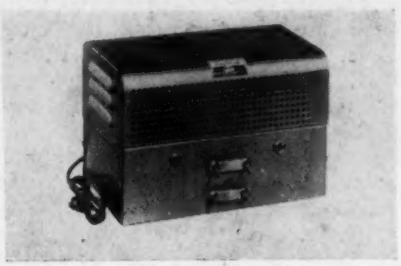


coil is increased. Designed for d-c use, only a small dry-disc rectifier is required for a-c service. The control resistor is separately mounted and connected with the contacts through the contact studs on the unit that is plugged into a socket. An illustrated bulletin is available.

### Low-Voltage Power Supply (46)

ELECTRO PRODUCTS LABORATORIES, INC., 549 West Randolph St., Chicago 6, Ill. The Model A power sup-



ply unit has been designed particularly for furnishing 6 or 12 volts of well-filtered d-c power for automobile, marine, and aircraft radio receiver testing. The unit weighs 31 pounds.

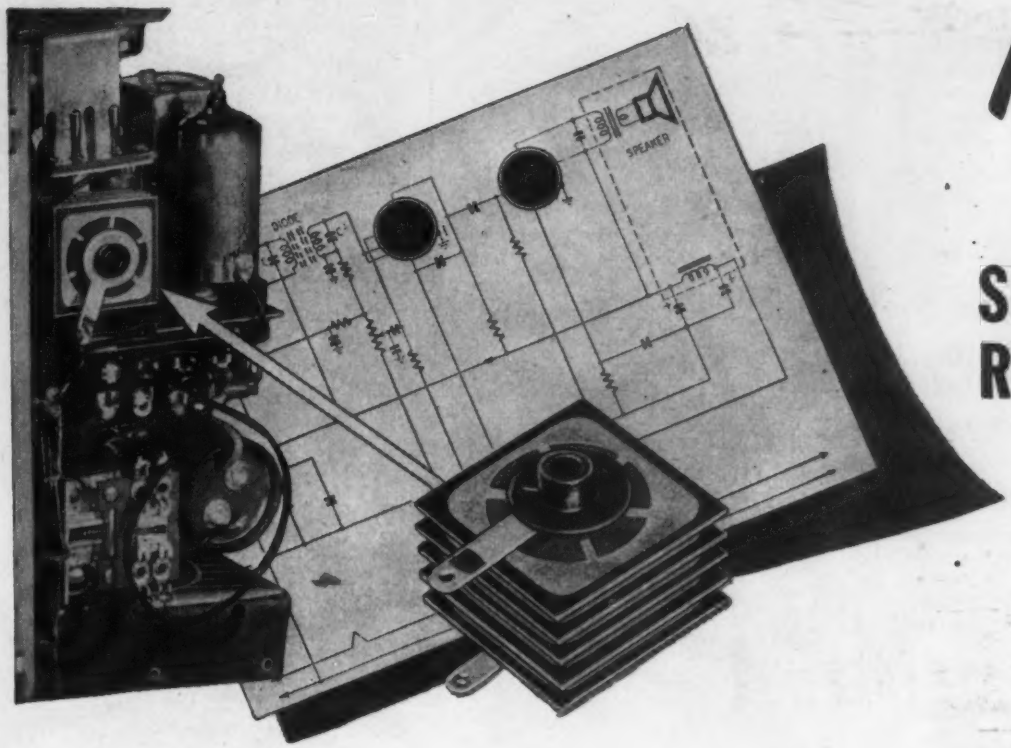
### Crystal Probe (47)

RADIO CORP. of America, Camden, N. J. The new type MI-8263 germanium crystal probe adapts the Voltohmyst and Chanalyst for circuit testing of television, frequency modulation and other vhf applications up to 100 mc.

### General Purpose Motor (48)

L & R MFG. Co., 577 Elm St., Arlington, N. J. The small motor illustrated is rated at 1/10 hp, 5,000 rpm, a-c or d-c and has a spindle with $\frac{3}{8}$ in. shaft extending both directions. It is equipped with

# simplifies design • saves installation time • cuts waste space




# NEW

## SELENIUM RECTIFIER

Taking *less than one cubic inch* of space, this new General Electric selenium rectifier has been designed to give new economies, new design possibilities to manufacturers of small radio sets. It's a cost-saver in all stages of production from the drawing board to the assembly line. Available now, to help you cut costs, it gives you these three big advantages:

***SIMPLIFIED DESIGN*** — A conventional circuit consists simply of a G-E selenium rectifier in series with a ballast resistor in one side of the line, feeding into a capacitor across the line.

***SMALLER ASSEMBLIES*** — This baby rectifier fits into spaces where tubes and sockets just can't go. It lets you design for smaller assemblies, smaller cabinets — gives you more room for other parts.

***LESS INSTALLATION TIME*** — Only two connections to make. Save time that's normally wasted in wiring for sockets and tubes. Cut assembly-line breakage losses and slowdowns.

Built for ample current capacity, the new General Electric selenium rectifier can stand up to the inverse peak voltages obtained when rectifying (half-wave) 110-125 volts rms, and feeding into a capacitor.

Normal operating temperatures of small radios were taken into consideration in the designing of the General Electric selenium rectifier. Ratings are based on ambient temperatures of 50 C to 60 C. Heavy varnish coating and spring contact construction provide uniformity of performance against variations of humidity and temperature.

Write for information that will help you to utilize the advantages of General Electric selenium rectifiers in your designs. Section A71-731, Appliance and Merchandise Department, General Electric Company, Bridgeport 2, Connecticut.

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*for Laboratory & Plant*

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Fifty-one models in a wide range of sensitivities for nearly every application. Spotlight Galvanometers with sensitivities up to 0.0006 μA per mm. Widely used in laboratory and production line testing, for deflection as well as null measurements. Bulletin 320.

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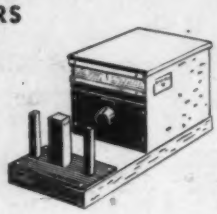
For rapid low-cost production testing of shorts and opens in coil windings of nearly every shape and size. Bulletin 109.



**LIMIT BRIDGES**

For rapid low-cost production testing of resistors from 1 ohm up to 10 megohms. Bulletin 100.

**DECADE RESISTANCE BOXES**

Thirty-five models covering the range from 0 to 100,000 ohms. Decade Resistors with increments down to 0.01 ohm available. Exceptionally sturdy construction assures long-term accuracy. Bulletin 100.

**STANDARD RESISTORS**

Reichsanstalt and National Bureau of Standards types from 0.001 ohm up to 10,000 ohms, limit of error 0.02% and 0.01%. Standard shunts from 0.00002 ohm to one ohm, limit of error 0.04%. Bulletin 100.

**SPECIAL INSTRUMENTS**

In addition to the partial listing of instruments above, the Rubicon Company produces a wide variety of special equipment involving in one way or another the precise measurement or control of some electrical quantity. Inquiries for equipment to meet special needs are invited.

**RUBICON COMPANY**

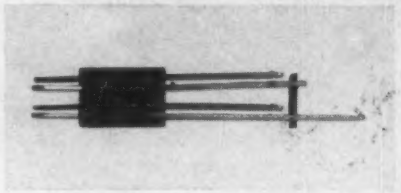
Electrical Instrument Makers

3757 Ridge Avenue • Philadelphia 32, Pa.

double ball bearings requiring no lubrication. The price, $33 fob, includes three-step pulley, foot rheostat and reversing switch.

### Contact Spring Assemblies (49)

P. R. MALLORY AND CO., Inc., Indianapolis 6, Ind. Three groups of contact springs can be assembled into many types of spring stackup



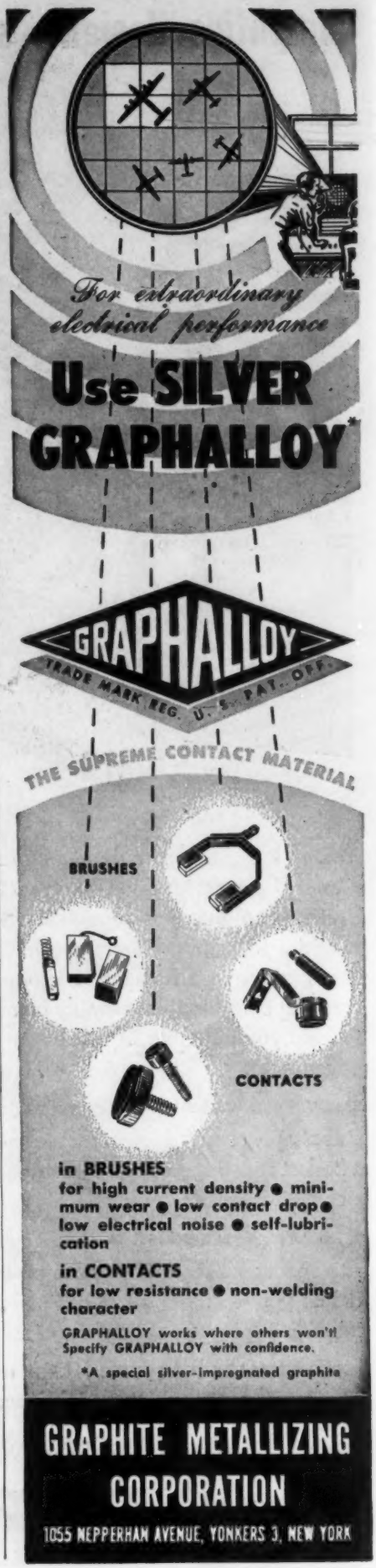
depending upon the needs of the circuit designer. Dimensional drawings on tracing paper are available. Additional information on this specification sheet includes alloys and contact materials for special uses.

### Remote-Control Tube (50)

RAYTHEON MFG. CO., Newton, Mass. The type RK61 subminiature thyratron is particularly adapted for radio control in model aircraft and boats. The tube can be used as a self-quenching superregenerative detector to operate a high-resistance relay in the anode circuit upon reception of a signal. Filament voltage is 1.4 v; current is 0.05 amp. Anode voltage is 45 v.

### Automatic Tube Exhaust (51)

EISLER ENGINEERING CO., Inc., 740 South 13th St., Newark 3, N. J. The type 24 head automatic exhaust machine can be used to manufacture bulbs up to the 1,500-watt size as well as the larger types for electronic tubes. Operation of the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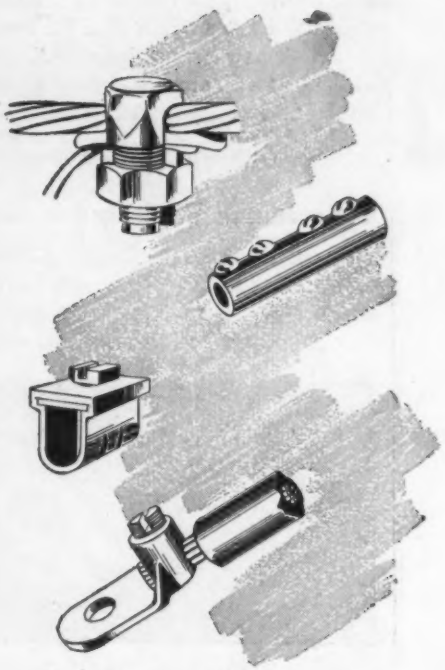
For full information concerning descriptions of items, location, packaging, and conditions of sale write to any of the above offices or visit your Customer Service Center. At the same time request that your name be placed on the Regional Office mailing list for this type equipment.



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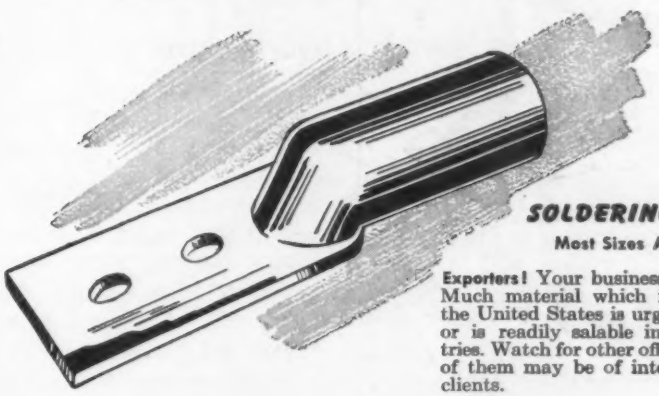
Many Types Available in Large Quantities.



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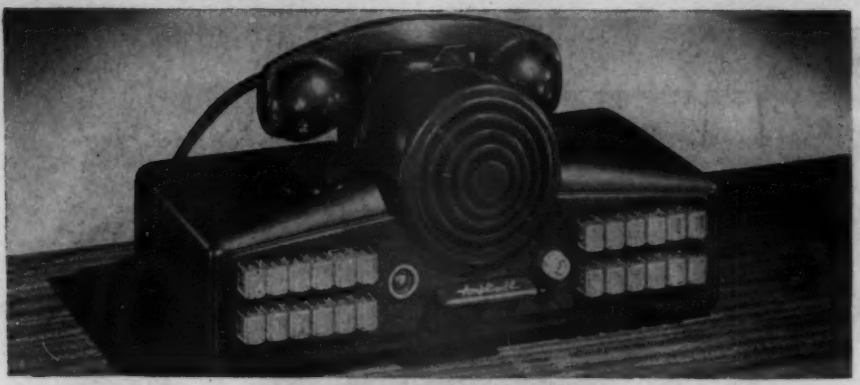

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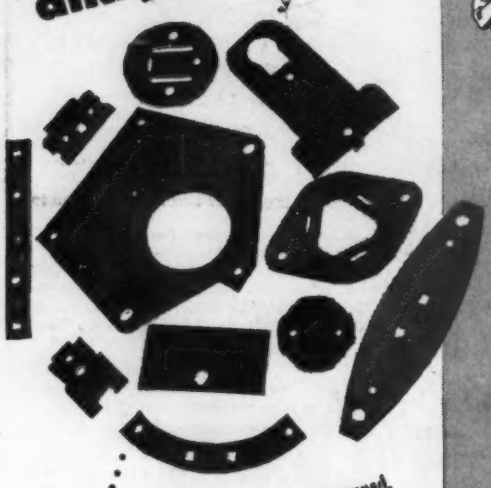
Baer can supply your vulcanized and phenol fibre fabrications



Baer fibre is versatile . . . can be stamped, punched, drilled, tapped, milled, sheared, sawed and shaved to specification

SEND BLUEPRINTS AND SPECIFICATIONS—NO OBLIGATION!

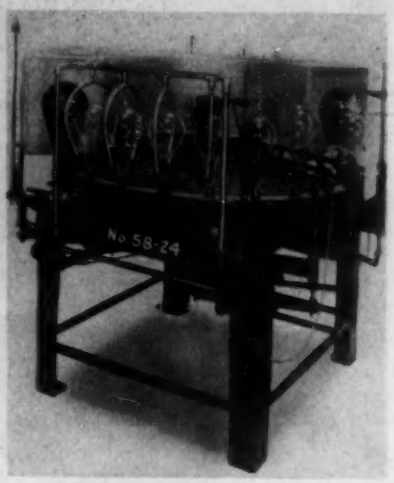
When you use these tough, lightweight and inexpensive parts, you build their many advantages *into your own product.* Fabricated to order, BAER FIBRE washers, special shapes, terminal boards, and other parts are accurately and uniformly produced to specification in any quantity. Selection of grades by physical and electrical qualities, permits application to a wide range of operating conditions and requirements. Investigate now!

*LITERATURE ON REQUEST*

N. S. BAER COMPANY

MONTGOMERY ST., HILLSIDE, N. J.





equipment is continuous and automatic, requiring only manual feeding and removal.

### Replacement Vibrators (52)

AMERICAN TELEVISION & RADIO Co., 300 East Fourth St., St. Paul, Minn. A new line of auto radio replacement vibrators has been developed and put into production.

### Capacitance Bushing (53)

ERIE RESISTOR CORP., Erie, Pa. The new type 2373 feed-through Ceramicon capacitor has been developed primarily as a heavy-current carry-

ing insulated bushing rated at 1,000 volts d-c for use on industrial heating and similar equipment.

### Railroad and Marine Speakers (54)

UNIVERSITY LOUDSPEAKERS, INC., 225 Varick St., N. Y. Four new speaker types, MIS, MIL, MM-2, MM-2F, ranging in power from 5 to 15 watts meet severe requirements of marine and railway installations. Dust, live steam, and salt

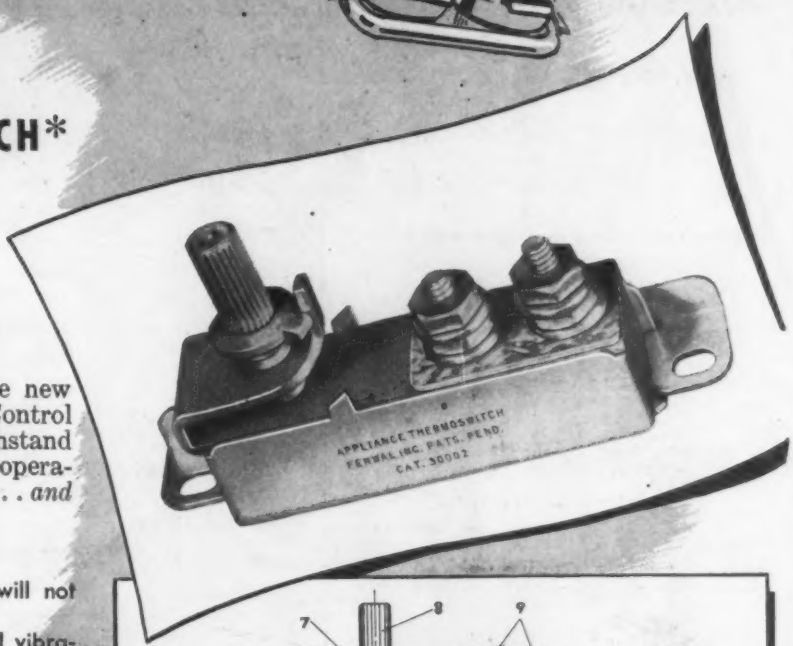
# If your product uses HEAT

## Specify

## THE *NEW* FENWAL APPLIANCE THERMOSWITCH* CONTROL

**Safe • Accurate • Long-Lasting Temperature Control For All Types of Electrical Appliances**

The unique and rugged design of the new Fenwal Appliance THERMOSWITCH Control provides a heat control unit that will withstand shock, vibration, tampering and other operational hazards that lower product life . . . *and influence buying attitudes.*




**Note these outstanding features:**

- Torque applied to terminal binding posts will not shift contact support members.
- Adjusting screw will not drift under normal vibration.
- The mounting bracket provides for side or bottom mounting, or a cross-mounting bracket is available for special applications.
- One-piece, welded case and cover assures rugged, tamper-proof unit . . . stable temperature settings.

### TWO DISTINCTLY DIFFERENT MODELS FOR HIGH AND LOW TEMPERATURE RANGES

The Appliance THERMOSWITCH Control is available in models especially designed for both high and low temperature ranges. The high temperature model provides control over the wide range of 50°F.–600°F. The low temperature model provides extremely critical control for low temperature applications throughout its range of 50°F.–250°F. Each model assures the highest degree of efficiency and dependability; both incorporate the outstanding Fenwal characteristics.

**SPECIFICATIONS**

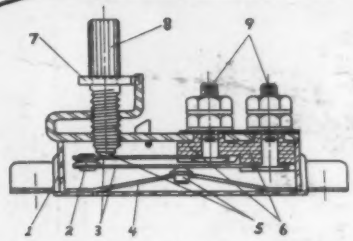
Overall case dimension: ½" high x ⅝" wide 2⅛" long.

Maximum Load Rating: 1200 watts on 110 volt 60 cycles.

TEMPERATURE RANGE:

50° F. to 250° F. (Series 30003)

50° F. to 600° F. (Series 30002)




1. Expanding stainless steel case.
2. Fine silver contacts.
3. Contact Supporting Members.
4. Low expansion metal bridge.
5. Ceramic Insulating Buttons.
6. Precision Ceramic Locator.
7. Stop Collar.
8. Adjusting Screw.
9. Terminal Binding Posts.

**RUGGED • COMPACT • LIGHTWEIGHT**

*Precision built*

**FOR FOOL-PROOF PERFORMANCE**

There is a Fenwal THERMOSWITCH Control to meet the requirements of most temperature control applications. Write for complete information.

Fenwal

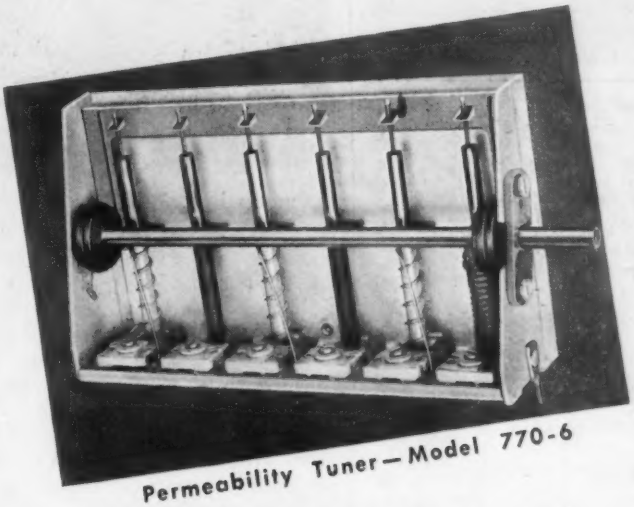
## FENWAL INCORPORATED

**43 PLEASANT STREET, ASHLAND, MASSACHUSETTS**

*T. M. Reg. U. S. Pat. Off.

# PERMEABILITY *Tuning*

## *A distinct advance for FM-AM Receiver Design*



Permeability Tuner—Model 770-6

1. Higher L/C ratios.
2. Freedom from microphonics.
3. Greater frequency stability.
4. Simplified wiring and switching.
5. Shorter H. F. leads.
6. All tuning elements in one integral unit.
7. Lower overall cost.

● This company has long pioneered the permeability tuning field and has secured a number of patents which disclose substantial improvements in that field. These patents are all available for licensing upon reasonable terms.

Please communicate with us if you would like to discuss the licensing of your company under these patents.

## JOHNSON LABORATORIES

DIVISION OF MANTLE LAMP COMPANY OF AMERICA

223 W. Jackson Boulevard, Chicago 6, Illinois

*Instantly—*

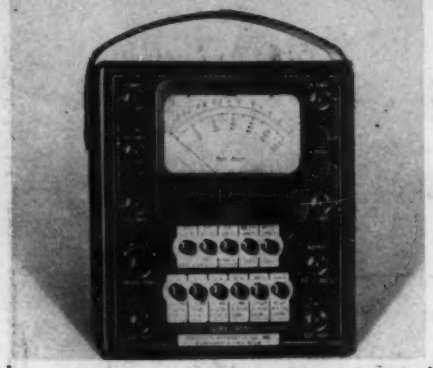
VOLTS
OHMS
MILS
DECIBELS
AMPERES
MICROAMPERES

*are at your fingertip!*

with the **NEW** Precision
*Multi-Master*
Series **858**

**20,000 and 1,000 ohms per volt**

***High speed, 54 range, dual-high sensitivity AC-DC de-luxe multi-range test set. Ranges to 6,000 volts — 600 megohms — 12 amperes — 70 DB — 60 microamperes.***



Automatic push button *range* and *function* selection. A supersensitive test set particularly engineered for reliable, high speed measurements in modern electronic circuits. Easy reading, 4½" meter. All standard functions at only two tip jacks. 600 megohm insulation resistance test range. Recessed 6,000 volt safety jacks. Etched-Anodized aluminum panels.

**RANGE SPECIFICATIONS**

★ 8 triple duty voltage ranges to 6,000 volts. Initial range 0-3 volts.
20,000 *AND* 1,000 ohms per volt D.C., 1,000 ohms per volt A.C.
★ 8 D. C. current ranges from 0-60 microamps to 12 amps.
★ 6 ohmmeter ranges to 600 megohms.
★ 8 D.B. ranges from —26DB to +70 DB
★ 8 output ranges to 6,000 volts.

Model 858-L; modern, shallow, bakelite laboratory type case, size 7⅞ x 8⅜ x 3 ..... $47.94

Model 858-P; portable, hardwood case with tool compartment and cover, size 8¾ x 10 x 4½ ..... $49.94
(complete with batteries and High Voltage test leads)

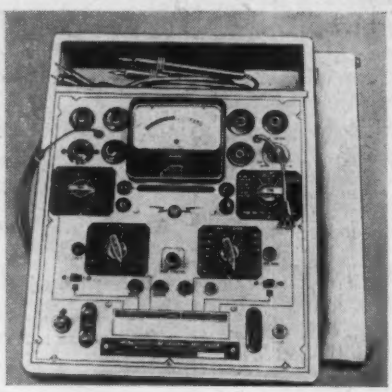
ASK to see the "Precision" line of Quality Test Instruments on display at all leading radio parts and equipment distributors. Signal Generators, V.T. V.M'S, Tube Testers, Multi-Range Test Sets, etc.

**PRECISION**
APPARATUS CO., Inc.
92-27 Horace Harding Blvd.
Elmhurst 10, N. Y.

spray have no effect upon their action. They are furnished with a flanged edge for flush cabinet mounting or with an adjustable bracket for wall mounting. Impedances are 8 or 15 ohms.

### Tube Tester (55)

RADIO CITY PRODUCTS Co., Inc., 127 West 26th St., New York 1, N. Y. A portable tube and set tester,



model 805B, combines a volt-ohm-milliameter, capacitor leakage tester, and roll chart for tube index. A germanium crystal diode rectifier is used for a-c measurements.

### Volt-Ohm-Milliammeter (56)

TRIPLET ELECTRICAL INSTRUMENT Co., Bluffton, Ohio. The Model 2450 electronic volt-ohm-milliammeter has two voltage regulator tubes to provide stability for both the positive and negative voltages, within a line variation range of 90 to 130 volts. Ranges include: d-c volts; 0, 2.5, 10, 50, 250, 500, 1,000; a-c volts, 0, 2.5, 10, 50, 250, 500, 1,000; d-c milliamps, 0, 0.1, 1.0, 10, 50, 250,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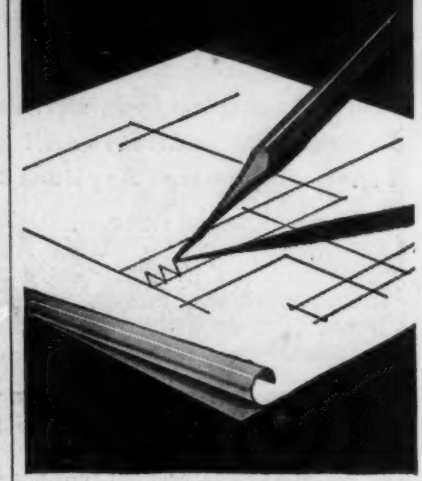
for
HARD PENCILS



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Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

**IMPERIAL PENCIL TRACING CLOTH**

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE.

# NOW— A QUALITY 2-KW INDUCTION HEATING UNIT

For Only $650.

Never before a value like this new 2-KW bench model "Bombarder" or high frequency induction heater . . . for saving time and money in surface hardening, brazing, soldering, annealing and many other heat treating operations.

Simple . . . Easy to Operate . . .
Economical Standardization of Unit
Makes this New Low Price Possible

This compact induction heater saves space, yet performs with high efficiency. Operates from 110-volt line. Complete with foot switch and one heating coil made to customer's requirements. Send samples of work wanted. We will advise time cycle required for your particular job. Cost, complete, only $650. Immediate delivery from stock.

Scientific Electric Electronic Heaters are made in the following range of Power: 1-3-5-7½-10-12½-15-18-25-40-60-80-100-250KW.—and range of frequency up to 300 Megs. depending on power required.

*Scientific Electric*

Division of
"S" CORRUGATED QUENCHED GAP CO.
107 Monroe St., Garfield, N. J.

DIALCO

# PILOT LIGHT ASSEMBLIES

## PLN SERIES—Designed for NE-51 Neon Lamp

*Features*

- THE MULTI-VUE CAP
- BUILT-IN RESISTOR
- 110 or 220 VOLTS
- EXTREME RUGGEDNESS
- VERY LOW CURRENT

*Write for descriptive booklet*

**The DIAL LIGHT CO. of AMERICA**
*FOREMOST MANUFACTURER OF PILOT LIGHTS*
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Telephone—Algonquin 4-5180

How to add "SELL" to your DIALS, PANELS & PLATES

Premier Dials, Panels and Nameplates combine maximum utility with the added PLUS of sales appeal. Sharp, clear and accurate! Rich colors and "baked-in" finishes! Premier metal products reflect this superiority in increased sales for you.

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- Monel
- Brass
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**PREMIER METAL ETCHING COMPANY**
*Quality Products for Over 35 Years*
43-27 21ST STREET, LONG ISLAND CITY 1, N. Y.

*Condensers for* BROADCAST-COMMUNICATION ELECTRONIC AND AMATEUR EQUIPMENT

*New Catalog #969 DG Free on Request. Specific Data furnished separately on larger types.*

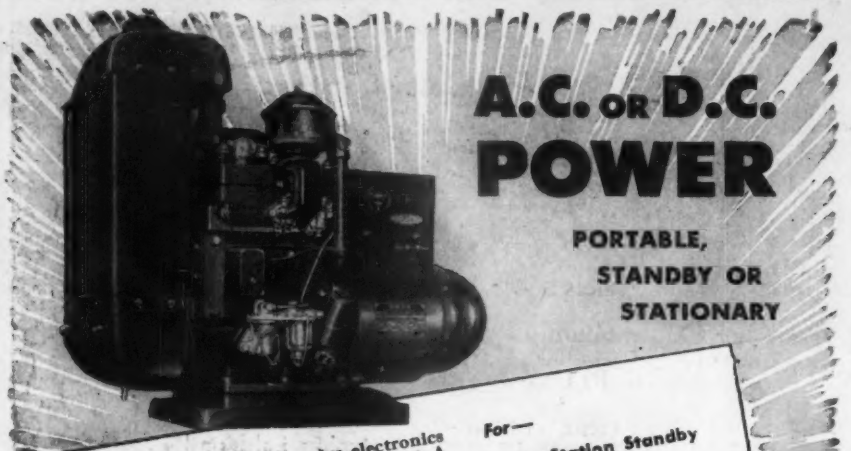
• The big JOHNSON condenser line offers an unequalled choice of types and sizes beginning with miniatures with .015" plate spacing, and extending through the pressurized types which offer RMS voltage ratings to 30,000 V. and capacities to 10,000 mmf. Each type is carefully designed by electronic engineers for maximum circuit efficiency. Many exclusive JOHNSON developments such as the heavy, beaded edge plates on commercial types not only increase electrical efficiency, but reduce mounting space, and through the savings in material, lower your costs.

*Johnson Products Include*

**Transmitting Condensers — Inductors — Tube Sockets — R. F. Chokes — Q Antennas — Insulators — Connectors — Plugs and Jacks — Hardware — Pilot and Dial Lights — Broadcast Components—Directional Antenna Equipment**

**JOHNSON** ... *a famous name in Radio*
E. F. JOHNSON CO. WASECA, MINNESOTA





**A.C. OR D.C. POWER**

**PORTABLE, STANDBY OR STATIONARY**

You can simplify any power-for-electronics problem with an ONAN Electric Plant. A wide range of models and sizes makes it easy to choose the right plant for the particular application.

Lightweight one or two-cylinder *air-cooled* models for easy portability—A.C.-350 to 5,000 watts, D.C.-600 to 5,000 watts. Onan two, four and six-cylinder *water-cooled* models are built for continuous heavy-duty operation, stationary or mobile. A.C.-3,000 to 35,000 watts, D.C.-3,500 to 10,000 watts.

ONAN Electric Plants: A.C.-350 to 35,000 watts in standard voltages and frequencies. D.C.-600 to 10,000 watts, 115 and 230 volts. Battery chargers—500 to 6,000 watts, 6 to 115 volts.

**D. W. ONAN & SONS INC.**
3564 Royalston Ave. Minneapolis 5, Minn.

For—
Radio Station Standby
Geophysical Survey
Railroad Radio
"Spot" Recording
Mobile Radio Units
Municipal Signal Standby
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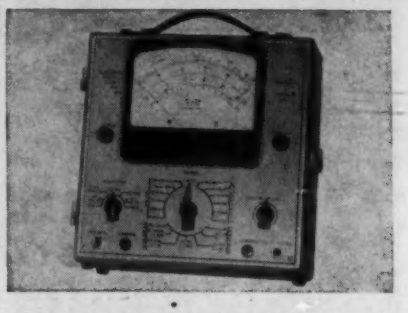
**ONAN ELECTRIC PLANTS**



1,000; ohms, 0 to 1,000 (midscale 10), 10,000 to 100,000; megohms, 0, 1, 10, 100, 1,000. capacitance in $\mu$f is 0, 0.05, 5, 50, 500.

### F-M Broadcast Antenna (57)

GENERAL ELECTRIC CO., Syracuse, N. Y. The doughnut f-m antenna unit illustrated shows the method

of mounting and feeding an antenna composed of these elements. Eight units give a power gain of seven.

### Water-Cooled Conductor (58)

TITEFLEX, INC., 517 Frelinghuysen Ave., Newark 5, N. J. A new water-cooled flexible, high-power, high-frequency conductor consists of a brass, water-tight convoluted inner core with an outer braided conductor. A high-frequency flexible insulation is extruded over the outer braid. Application of the conductor to high-frequency heating equipment and similar use is expected.

## Literature

(59)
**Metallized Capacitors.** Solar Manufacturing Corp., 285 Mad-

ison Ave., New York 17, N. Y. Full details of the new aluminized paper capacitors are found in Bulletin SPD-110, now available. Designers of electronic equipment are offered a combination of small size and light weight at standard voltage ratings.

(60)
**Laboratory Hygrometer.** Serdex, Inc., 91 Cambridge St., Boston 14, Mass. Percentage of relative humidity important to many manufacturing and testing conditions can be read to within plus or minus 1.5 percent using the type HGS-HY-1 described in Bulletin 201.

(61)
**Perfect Amplification.** Amplifier Corp. of America, 396 Broadway, New York 13, N. Y. Twenty steps to perfect amplification, or how to get the most out of music, is described in a 24-page booklet by the company's chief engineer. Many unusual features, from direct coupling to cross modulation, are covered. The booklet is available upon receipt of a three-cent stamp.

(62)
**Welding Control.** Westinghouse Electric Corp., P. O. Box 868, Pittsburgh, 30, Pa., announces a booklet (B-3839) on Synchro-Trol. Here is a new line of synchronous-precision, a-c resistance-welding controls in a complete, unified, factory-assembled package. An 18-page illustrated booklet lists the eight basic subunits from which designers or manufacturers can select the units necessary for resistance-welded products.

(63)
**New Bulletins.** Wheelco Instruments Co., 847 W. Harrison St., Chicago 7, Ill., announces the issuance of a new bulletin. Electronic controls in general, with listings and specifications, are covered in Bulletin Z6400.

(64)
**Thermal Protector.** Manning, Maxwell, and Moore, Inc., Bridgeport 2, Conn. The recently prepared folder on the Ashcroft Thermal Protector


# R-MC TRANSCRIPTION PLAYER

***Model TP-16C TURNTABLE and CASE only***
***(Patents applied for)***

*Two-Speed . . . 16-inch . . . Low Price . . . Portable*
*Compact . . . Lightweight . . . Easy to Carry . . .*

*In carrying position: 23" w., 17½" h., 8" d.*

**Designed and built to meet the quantity production demand for a fine tone, dependable, and very low price transcription player. Available immediately. Advanced design, expertly engineered, and sturdily-built for trouble-free performance. Meets the demands of radio stations, transcription services, advertising agencies, and schools for realistic reproduction of transcription records up to 16 inches, 78 or 33 1/3 r.p.m. Free of wow and rumble. Switch output impedance: 30, 250, and 500/600 ohms.**

**Constant speed heavy duty motor, silent, smooth operation. 16" TURNTABLE embodies special re-enforced construction (patent pending).**

**Supplied with or without professional broadcast station Reproducers. More than 1500 of these PARA-FLUX magnetic Reproducers are now on the air over FM-AM stations. Reproducer, with interchangeable heads for Vertical, Lateral, or Universal, uses same Arm and Equalizer. Model EL-2 Equalizer is of new design with all components enclosed in one compact housing.**

***Available immediately through Authorized Jobbers***

***Descriptive Bulletin TP6, upon request.***

**RADIO-MUSIC CORP.**
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The AVIMO Film Assessor has been designed for the projection of 35mm or 16mm Film of Oscillograph Traces or other phenomena. Frames are projected singly or continuously on to an optically flat surface and magnification is from x12 to x36. Projection of successive frames is accurate to within ± .0036 at maximum enlargement.

*AVIMO Continuous Film Recording Cameras provide permanent records of oscillograph traces.*

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*Designers and Manufacturers of Scientific Cameras*

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*Speakers make the*

# DIFFERENCE

## *. . . and what a* DIFFERENCE!

General Electric Speakers are built to be different—better. For warm, live, pulsating radio and record reproduction, specify speakers by General Electric.

- **Better tone quality**
- **High wattage handling capacity**
- **No warping of voice coil**
- **Greater design possibilities**
- **Overall greater efficiency**
- **Better controlled air gaps**
- **Rigidity, strength, durability**

Consult General Electric now for your Speaker requirements. Write to: *General Electric Company, Electronics Department, Syracuse 1, N. Y.*

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*Intricate Fabricating*

LET OVER TWENTY YEARS OF EXPERIENCE GUIDE YOU

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**ELECTRICAL INSULATION CO., INC.**

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- Specialists in the production of highest grade Alnico Magnets.
- Production and material rigidly inspected to assure highest uniform quality.
- Castings made to order from customer's blueprints or sketches.
- Information and suggestions supplied on request.

*Manufacturers of High Coercive Magnetic Alloys*

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GENERAL MAGNETIC CORPORATION

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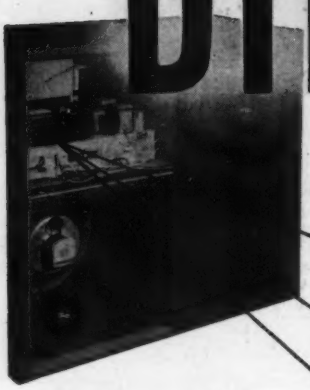
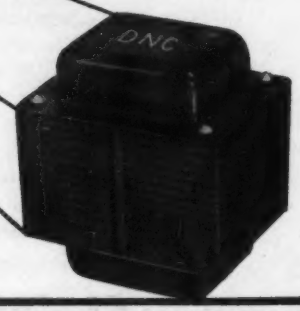
STROMBERG-CARLSON *uses*-

# DINION

*Transformers and Coils*



- Photo Flash Control • Instrument • Television
- Radio • Electronics and Industrial Applications
- Electrical Coil Windings




The stringent requirements of a radio of distinction call for high calibre transformers and electrical coil windings. For superior quality and production, manufacturers use Dinion Transformers and Coils.

Specialists in Difficult Designs

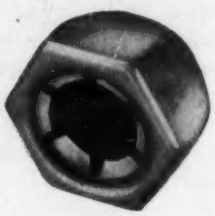
**DINION COIL COMPANY, INC.** CALEDONIA NEW YORK

# *Where Can* YOU *Use*

## SELF-LOCKING ACORN PALNUTS?

• Self-locking Acorn Palnuts are dome shaped, single thread locknuts made of tempered spring steel. They exert a powerful double-locking action that defies loosening under vibration. Low in cost—light in weight—easily, speedily applied—require but 3 bolt threads space to lock effectively.

HERE ARE THE FEATURES:



- Self-locking; replaces regular nut and lockwasher
- Holds tight under vibration
- Covers rough unsightly bolt ends, eliminating "catching" or "scratching"; adds streamlined appearance
- Saves assembly time, labor, weight and cost

**INVESTIGATE** Acorn Palnuts for your products. Outline your needs for samples and suggestions. Write for literature giving data on Self-locking Palnuts.

**The PALNUT Co.**
77 CORDIER ST., IRVINGTON 11, N. J.

gives a complete description of the "fail-safe" electronic limit switch, with specifications and wiring diagram.

(65)

**Communication Equipment.** Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa., has a new 44-page booklet (B-3610) which provides designers of communication and electronic equipment with a quick list of products available for their use. It covers parts and materials for radio transmitters and receivers, radar, telephone apparatus, electronic heating sets, and electronic control.

(66)

**Insulation Tester.** James G. Biddle Co., 1316 Arch Street, Philadelphia 7, Pa. Bulletin 21-60 illustrates and describes the "Bridge-Meg" type of megger insulation and resistance tester. Engineers, electricians, and maintenance men will find this instrument most useful. Copies of the 12-page, slick-papered bulletin can be obtained on request.

(67)

**Ferro-alloys.** Electro Metallurgical Sales Corp., 30 E. 42nd St., New York 17, N. Y. A concise review of information on ferro-alloys is provided in a 64-page booklet. Interesting historical data are included along with typical analyses to assist users in selecting for specific applications.

(68)

**Temperature Control.** Wheelco Instruments Co., 847 Harrison St., Chicago 7, Ill. A valuable guide for anyone interested in process instrumentation is the 20-page Educational Bulletin No. 5. Included are charts, tables and diagrams explaining measurement and automatic control and the selection of proper control systems for process applications.

(69)

**Depth Recorder.** Bludworth Marine, 100 Gold St., New York 7, N. Y. For the latest in electronic navigation aids look to the group


Subminiature electrometer tubes

Twin hearts to the circuit requirements

Geiger-Mueller Counters

Sharing the problem of nuclear measurement

Consider these factors for research . . . laboratory . . . production:

1. Low filament drain 10 milliamperes.
2. High input resistance $10^{16}$ ohms.
3. Versatility in instrumentation for chemical, oil, nuclear physics research, etc.
4. Ideal for electrometer applications.
5. Extreme portability—low battery drain.

The VG series mica window Geiger-Mueller Counters are of precision workmanship and superior design. Exacting production controls assure a counter held within close tolerance limits. Designed to meet the ever increasing demand for reproducibility of tracer measurements.

Victoreen hi-megohm resistors are specially designed for the hard applications where stability with long life is required. Designed for laboratory use and fine instrumentation. Vacuum sealed in glass to cover a range of 100 to 10,000,000 megohms.

Write for technical data booklet on tubes and resistors.

Model 337

Complete Geiger-Mueller Counting System

A complete Geiger-Mueller counting system and a top ranking laboratory instrument. It utilizes a scale of 64 with provisions for switching to a scale of 8. A built-in a.c. power supply provides voltages continuously variable from 0 to 2000 volts. Two new Victoreen gaseous voltage regulator units and a reliable impulse register are included. Complete and convenient front panel switching and control.

THE VICTOREEN INSTRUMENT CO.
5806 HOUGH AVENUE
CLEVELAND 3, OHIO

# speed production—cut costs with EJECT-O-MATIC

## AUTOMATIC-FEED SOLDERING IRONS AND ACCESSORIES

**HEAVY DUTY EJECT-O-MATIC**

High-heat 100 and 150-watt models for general heavy electrical, electronic and repair work. Also available in long-nosed "instrument" model. Weight only 22 oz.

**STANDARD EJECT-O-MATIC**

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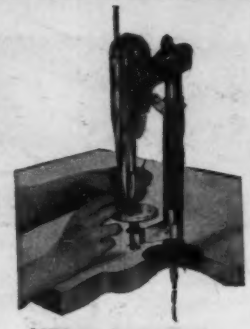

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of four 4-page illustrated folders on the ultrasonic echo depth recorder. Also described is a direction finder for safe sailing regardless of visibility or adverse weather conditions.

(70)
**Industrial Metals.** D. E. Makepeace Co., Attleboro, Mass., has issued an interesting new folder treating laminated and solid precious metals for industrial use, and particularly its bar contact raised lay, for the manufacture of arm or leaf contacts. The company has a special folder going into the subject more thoroughly which will be mailed on request.

(71)
**Resistors.** Precision Resistor Corp., 334 Badger Ave., Newark 8, N. J. A new bulletin illustrates 19 inductive and non-inductive types. Included is a free sample as a guide for numerous wire-wound resistor applications. Copies of the latest catalog may be had on request.

(72)
**Inserts.** Aircraft Radio Corp., Boonton, N. J. Those who already have the catalog of "Accessories and Component Parts for Radio and Electronic Equipment" will want a series of new bulletins recently issued that describe connectors and microwave equipment. The sheets are specially punched for ready insertion in the file.

(73)
**Technical Index.** Radio Corp. of America, Princeton, N. J. The new index of RCA Technical Papers in two volumes lists all papers on subjects in the radio, electronic and related fields authored by RCA employees. Both chronological and alphabetical lists are given. Copies may be obtained free of charge upon request.

(74)
**Cooling Equipment.** Rotron Division, Jenckes Knitting Machine Co., 180 Weeden St., Pawtucket, R. I. A catalog is available describing blowers and parts designed specifically for use in radio-


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frequency equipment. Standard units are illustrated; others, now under design, are mentioned.

(75)
**Reproducers.** Radio-Music Corp., 136 Liberty St., New York 6, N. Y. Minute details of Para-Flux reproducer features may be found in a four-page brochure on the subject. The instrument has many readily apparent fields of use particularly in a-m and f-m broadcasting.

(76)
**Resistors.** P. R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis 6, Ind. Request Form No. VER-1146 for an 8-page amply illustrated booklet on vitreous enamel fixed and adjustable power resistors designed for industrial electronic applications.

(77)
**Tube Manual.** General Electric Co., Electronics Dept., Tube Division, Building 267, Schenectady 5, N. Y., has made available a new 700-page technical manual on receiving tubes, for manufacturers and designers of electronic equipment. Prepared with an expander-type binder, in a stiff leatherette cover, it sells for five dollars, which includes service through 1948. In 1949 further inserts will be available at one dollar a year.

(78)
**Folded Antenna.** Andrews Co., 363 E. 75th St., Chicago 19, Ill. Bulletins 38A and 737 describe the improved signal strength in the 30-to-44 mc band provided by the folded unipole antenna. The vertical trombone radiating element provides ideal impedance match for a 70-ohm transmission line.

(79)
**Squarewave Generator.** Reiner Electronics Co., 152 W. 25th St., New York 1, N. Y. On two sides of a page we find a detailed report of the model 530 squarewave generator for use in production and general testing. Its chief features are the facility of synchronization with any external frequency source, a hand-calibrated frequency scale reading from 10 to


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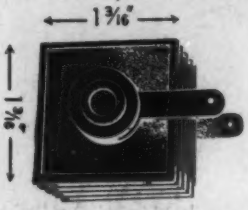


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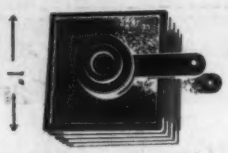


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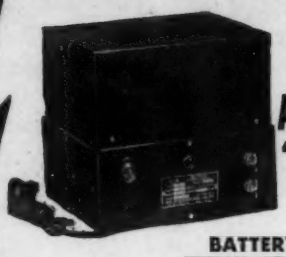

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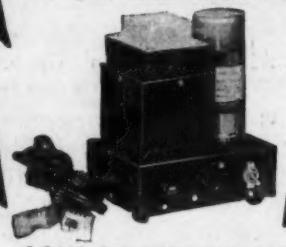

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| Min. sensitivity Class Q, ua/l | 180 | 55 | 130 | 36 | 160 |
| Red-Sensitive S1 | CE-28 | CE-28 | CE-30 | CE-30-V | CE-31-V |
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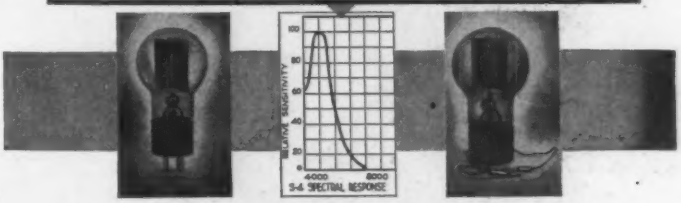
| Min. sensitivity Class R, ua/l | 90 | 90 | 75 | 25 | 25 |
| Min. sensitivity Class Q, ua/l | 180 | 180 | 165 | 55 | 55 |

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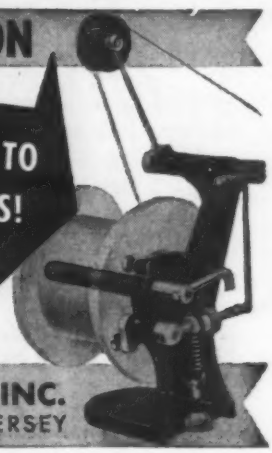

The free-running action of the PAMARCO tension practically eliminates defective coils. Their compact size permits more simultaneous coil winds on *any* machine. Operator makes all adjustments for any gauge wire with simple thumbscrew.

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Aerials

EXPORT DEPARTMENT: C. W. Brandes, Manager, 4900 Euclid Ave., Cleveland 3, Ohio
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100 cycles and a decade frequency multiplier to extend the range to 100 kilocycles.

(80)

**Capacitors.** Chicago Condenser Corp., 3255 W. Armitage Ave., Chicago 47, Ill. A small bulletin contains much data on a variety of capacitors, all non-inductively wound, having tinned copper leads.

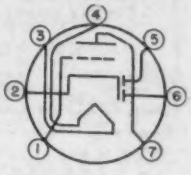
## Tube Registry

**The information furnished by the RMA Data Bureau has been abridged and only the more significant dimensions are given.**

### Type 6AV6

Double diode, high-mu triode, heater type; T-5½ integral glass envelope-base; 7-pin button base.

$E_f$ = 6.3 v
$I_f$ = 0.3 amp
$C_{in}$ = 2.3 μμf
$C_{out}$ = 0.9 μμf
$_pC_g$ = 2.1 μμf




6AV6

Typical Class $A_1$ Operation

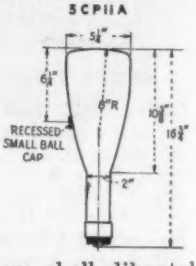
$E_b$ = 250 v
$I_b$ = 1.2 ma
$E_c$ = − 2 v
$r_p$ = 62,500 ohms
μ = 100
$g_m$ = 1,600 μmhos

### Type 5CP11A

Cathode ray tube, heater type, electrostatic focusing and deflection,

$E_f$ = 6.3 v
$I_f$ = 0.6 amp
*Typical Operation*
$E_{a2}$ = 4 kv
$E_{a1}$ = − 2 kv
$E_{a4}$ = 400 to 600 v
$E_{g1}$ = − 90 v (max) for cutoff
$D_1$ and $D_3$ = 78 to 106 v. per in.
$D_2$ and $D_4$ = 66 to 90 v per in.

5CP11A




P11 screen, medium shell diheptal 12-bin base.

### Type 5513

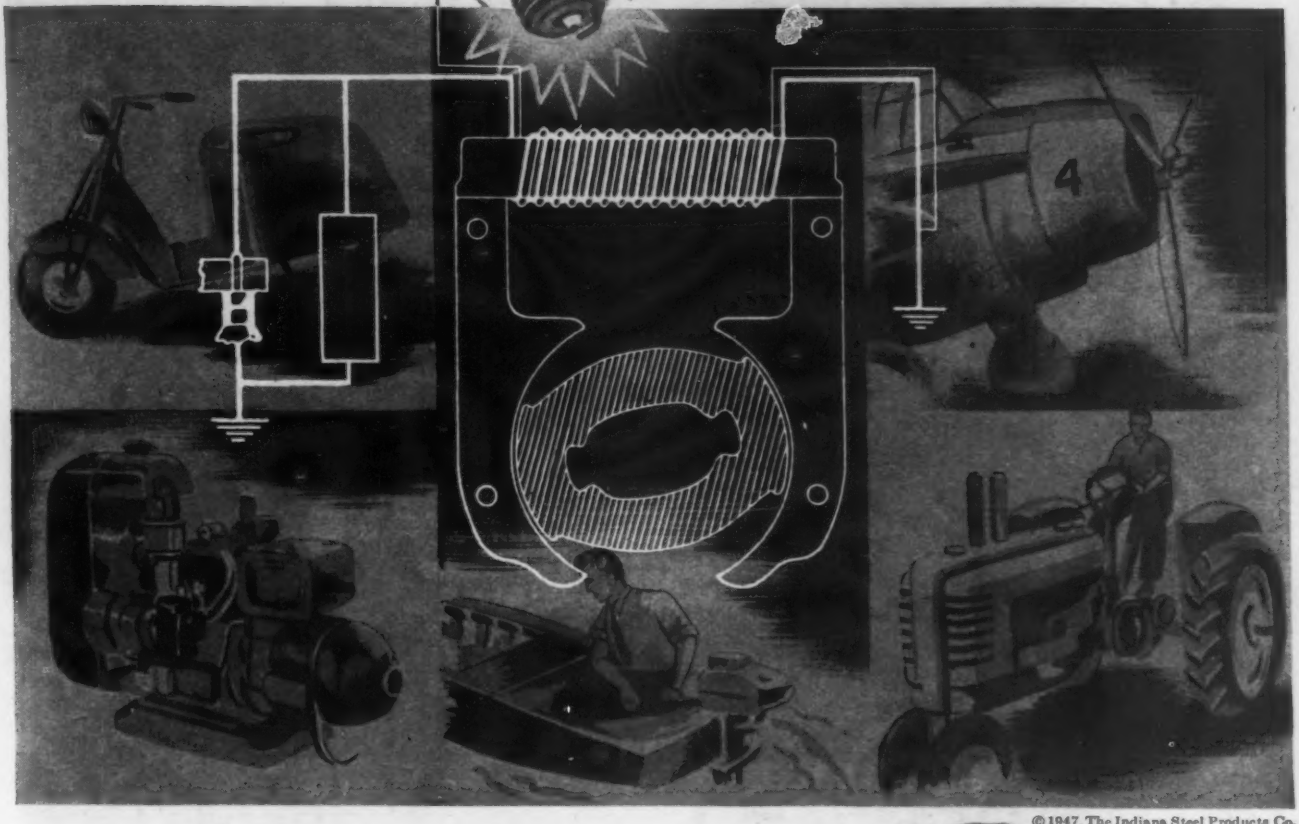
Triode power amplifier and oscillator, forced air cooled, filament

# PERMANENT MAGNETS MAY DO IT BETTER

## Magnets are hot stuff

In aircraft, motorcycles, speed boats, tractors, motor buses—internal combustion engines which must maintain highest efficiency depend upon the magneto. Unfailingly, it provides a HOT SPARK. After prolonged periods of idleness, magneto-equipped engines kick over instantly, even after they have been subjected to adverse temperatures or excessive moisture. The "Packaged Energy" of the permanent magnet within the magneto is the secret of this exceptional performance.

Magnetos made several decades ago are still functioning efficiently. Today, however, the development of Alnico magnetic materials has made possible the production of modern magnetos which, though amazingly more compact in design, are even more efficient in performance.



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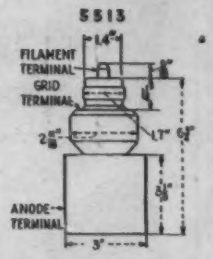
WIRE PRODUCTS Jelliff SINCE – 1860


NEW PRODUCTS (continued)




$E_f$ = 6.3 v
$I_f$ = 32
$C_{in}$ = 21 μμf
$C_{out}$ = 0.11 μμf
$C_p$ = 8.7 μμf
$E_b$ = 4 kv (max)
$I_b$ = 1.0 amp (max)
$W_p$ = 1,200 watts (max)

type. At $I_b$, 0.4 amp and $E_c$, 10 v, $\mu$ is 87

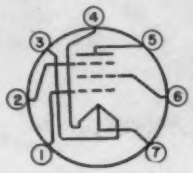
### Type 2E30

Beam power amplifier and oscillator; filament type; T-5½ integral glass envelope-base; miniature 7-pin button base. Filament heating time approximately 0.2 second. Maximum power output 10 watts.

$E_f$ = 6/3 v
$I_f$ = 0.65/1.3 amp
$C_{in}$ = 9.5 μμf
$C_{out}$ = 6.6 μμf
$C_{p-1}$ = 0.2 μμf

Typical Class $A_1$ Operation

$E_b$ = 250 v
$E_{c1}$ = −20 v
$E_{c2}$ = 250 v
$E_{c3}$ = 0 v
$I_{b2}$ = 40 ma
$I_b$ = 44 ma (max sig)
$r_p$ = 63,000 ohms
$r_1$ = 4,500 ohms
$G_m$ = 3,700 μmhos
$W_{out}$ = 4.5 watts (8 percent)




2E30

### Type 5563

Triode thyratron, filament type, mercury vapor. Maximum ratings with mercury temperature 25 to 50 C and operation 25 to 125 cps.

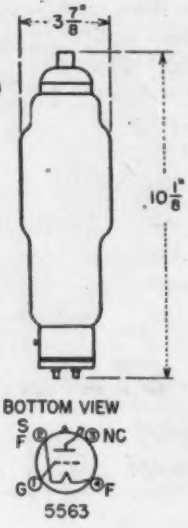
$E_f$ = 5 v
$I_f$ = 10 amp
$E_{drop}$ = 15 v
$C_{in}$ = 20 μμf
$C_p$ = 10 μμf

Control (referred to pin 2)

$E_c$ ($E_b$ = 1,000 v) = −70 v
$E_c$ ($E_b$ = 1,000 v) = −8 v
Critical $E_b$ at 0 v = 150 v

Maximum ratings

$E_b$ = 15 kv (peak forward)
$E_{inv}$ = 15 kv (peak)
$I_{surge}$ = 200 amp (0.1 sec)
$I_b$ = 6.4 amp (peak)
$I_c$ = 1 amp (peak)
$I_b$ = 1.6 amp (average 1 cycle)
$I_c$ = 0.1 amp (average 1 cycle)
$E_c$ = −500 v (before conduction)
$E_c$ = −10 v (after)




5563


**A major advancement in the recording blank field . . .**

*10 Year*

**GUARANTEE**

**GOULD-MOODY**

***"Black Seal"***

**ALUMINUM RECORDING BLANKS**

After prolonged research and experimentation, we have introduced technological improvements into "Black Seal" blanks that not only increase life span, but materially enhance the other finer characteristics of these blanks. And so positive are we of the worth of these perfected "Black Seals" that we're offering them to you on an unconditional ten-year guarantee basis.

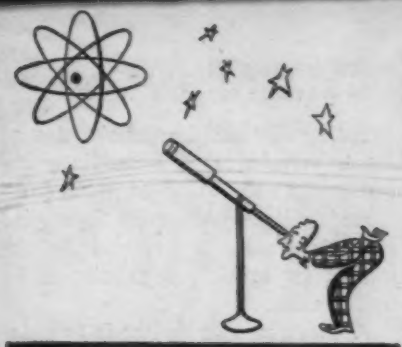
***You can't afford to be a recording isolationist . . .***

"Black Seal" blanks will not rip up, disintegrate or powder after the first playing if kept in storage for any long period of time. You are in no danger of losing valuable recordings in what, up until now, you have considered your safe library of recording blanks. No matter how well you may be satisfied with your present blanks, you can't afford to be a recording isolationist. Try "Black Seal"—if, for any reason whatsoever, you aren't satisfied, return them at our expense.

THE GOULD-MOODY CO.

*Recording Blank Division*

395 BROADWAY NEW YORK 13, N. Y.



IF YOU ARE AN EXPERIMENTER
IN THE ELECTRONIC FIRMAMENT,
YOU'LL WANT TO USE
LAFAYETTE
AS SUPPLY HEADQUARTERS.
EVERY STAR IN THE
GALAXY OF EQUIPMENT AND
PARTS MANUFACTURERS
IS CATALOGUED AT . . .

**Lafayette**

**RADIO WIRE TELEVISION, INC.**

**FOR RADIO & ELECTRONIC EQUIPMENT**

**100 SIXTH AVE., NEW YORK 13**
**110 FEDERAL ST., BOSTON 10**
**24 CENTRAL AVE., NEWARK 2**

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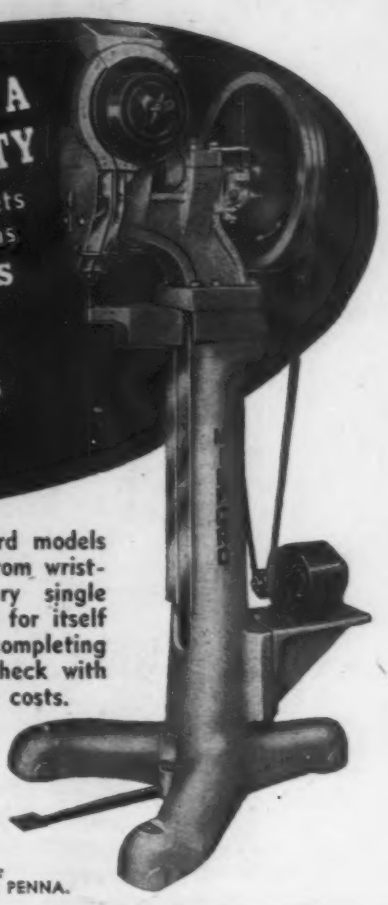
**MILFORD FASTENING EQUIPMENT**

MODEL No. 300-A

**FOR EXTRA HEAVY DUTY**

sets semi-tubular or split rivets in such diverse assemblies as

**WASHING MACHINES**
**STEAM PUMPS**
**SKATES • SAWS**
**REFRIGERATORS**
**CHAINS, etc.**



Here is another of Milford's 15 standard models of rivet-setters for assemblies ranging from wrist-watch bracelets to refrigerators. Every single Milford rivet-setter has more than paid for itself either in cutting costs of assemblies or completing them faster. For any fastening need, check with Milford — for ideas to save time or cut costs.

**THE MILFORD RIVET & MACHINE CO.**

**859 Bridgeport Avenue, Milford, Conn.**
**1002 West River Street, Elyria, Ohio**
*Inquiries may also be addressed to our subsidiary:*
THE PENN RIVET & MACHINE CO., PHILADELPHIA 33, PENNA.

---

**Lavite** **STEATITE CERAMIC**

**Properties and Characteristics of Our LAVITE S1-5 Steatite Ceramic Body**

| | | |
|---|---|---|
| Compressive Strength | 96,000 | lbs. per square inch |
| Tensile Strength | 7,200 | lbs. per square inch |
| Flexural Strength | 10,500 | lbs. per square inch |
| Modulus of Rupture | 20,000 | lbs. per square inch |
| Dielectric Strength | 235 | volts per mil |
| Dielectric Constant | 6.42 | Frequency of 1 megacycle |
| Loss Factor | 2.90 | |
| Power Factor | .446 | |
| Bulk Specific Gravity | 2.664 | |
| Density (from above gravity) | 0.096 | lbs. per cubic inch |
| Hardness (Mohr scale) | 7.0 | |
| Softening Temperature | 2,350°F. | |
| Linear Coefficient of Expansion | 8.13x10⁻⁶ | |
| Moisture Absorption (ASTM D-116-42-A) | 0.009% | |

Design engineeers and manufacturers in the radio, electrical and electronic fields are finding in LAVITE the precise qualities called for in their specifications . . . high compressive and dielectric strength, low moisture absorption and resistance to rot, fumes, acids, and high heat. The exceedingly low loss-factor of LAVITE plus its excellent workability makes it ideal for all high frequency applications.

We will gladly supply samples for testing.

**D. M. STEWARD MFG. COMPANY**
Main Office & Works: Chattanooga, Tenn.
Needham Mass. Chicago Los Angeles

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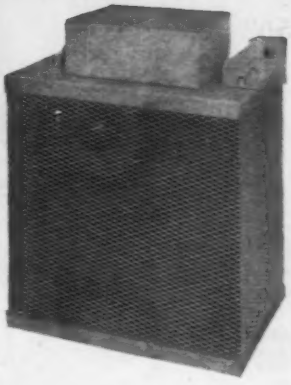
## . . . a complete range of

# POWER TRANSFORMERS

## capacities to 50 KVA



**No ELECTRAN Transformer is considered a "stock" model. Each is built to function with maximum efficiency for a specific installation.**

**Electran production facilities are completely flexible and are especially geared for the rapid completion of small or medium quantities. Engineering facilities permit production of Transformers to your exact specifications or prints, or the complete design and engineering of Transformers to meet your specific needs when your prints are not available. Your inquiries are invited.**

# ELECTRAN MFG. CO.

**4589 ELSTON AVE.** **CHICAGO 30, ILL.**

ANOTHER
SPECIAL BY
PROGRESSIVE
QUALITY PROMISED AND MADE
BLUE PRINT
ACTUAL SIZE
ENLARGED FOR DETAIL
CATALOG SHOWS DOZENS MORE
Special heads, threads and finishes on any metal or alloy adapted to cold upset. Weekly output: 25,000,000 pieces. Many specials, suggesting production savings for you, illustrated in latest catalog. Includes weights per 1M standard pieces, decimal equivs. of fractions, other purchasing and engineering helps. Write for Catalog 18.
The PROGRESSIVE MFG. CO.
50 NORWOOD ST. TORRINGTON, CONN.

3 WAYS TO BE AHEAD
in Buying Test Equipment
1 BUY ACCURACY
2 BUY DEPENDABILITY
3 BUY SUPREME-ACY
Model 599-A Tube and Set Tester
SPECIFICATIONS
DC Volts — 5 ranges 0/6/15/150/600/1500 volts. 1000 ohms per volt.
AC Volts — 4 ranges 0/15/150/600 volts.
DC Current — 3 ranges 0/6/60/600 milliamps.
Output Volts—0/15/150/600 volts.
Ohmmeter — 4 ranges 0/200/20,000 ohms and 0/2/20 megohms.
Condenser Checker—Ohmmeter provides fast method of checking leakage of both paper and electrolytic condensers.
Battery Tester — Tests most commonly used dry portable batteries of 1.5/4.5/6.0/45/90 volts. English reading "Replace-Good" scale.
Ask your nearest SUPREME jobber for a demonstration of Model 599-A Tube and Set Tester (above), Model 561-AF & RF Oscillator, Model 546-A Oscilloscope, Model 592 Speed Tester. Ask to see the complete line of SUPREME equipment.
SUPREME
Tube Testing — Circuit incorporates proven and modernized emission circuit. Checks for short, leakage, and noise tests between elements.
Power Supply—100-133 volts—50/60 cycles. Special voltages and frequencies on request.
WRITE FOR NEW CATALOG
SUPREME INSTRUMENTS CORP., Greenwood, Miss., U.S.A.
Export Department: THE AMERICAN STEEL EXPORT CO. Inc., 347 Madison Ave., New York 17, N. Y., U.S.A.




creasing the echoing efficiencies of small vessels is of immediate importance, and study of the conditions under which such increased echoing efficiencies should be required on small vessels should be undertaken.

A chart comparison unit is a desirable but not essential auxiliary device.

The Administrations of the various countries should, seperately and independently, examine the question of the qualifications required of personnel certificated or licensed to operate or maintain shipborne radar equipment.

The question of charts for use with radar should be coordinated with the chart requirements for other navigational aids.

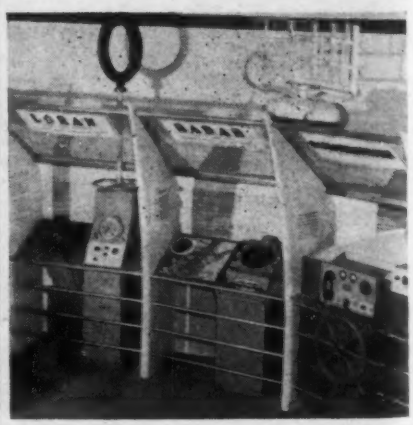
Shore-based radar has many possible applications to maritime usage, and operational trials should continue.

The time has not yet come for world standardization restricting shipborne radar to a single frequency band. It is desirable that operational trials should continue with shipborne radar operating in the range between 3,000 and 10,000 mc.

A true bearing display is very desirable but not indispensable.

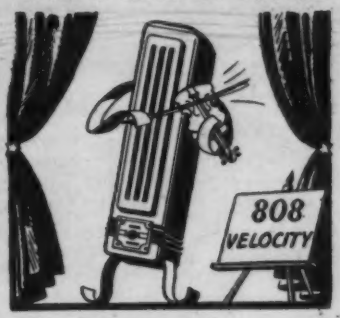
## RCA Opens Exhibit

TO FAMILIARIZE the public with products and services of Radio Corporation of America, a huge showroom has been set up extending for more than 190 feet along 49th




The marine radio section of the RCA Exhibition Hall shows postwar commercial versions of loran, radar, and radiotelephone equipment

WHO'S WHO IN SOUND




**Big Entertainment Favorite**

Star of stage and indoor programs. Smooth responding, good looking. Bi-directional without feed-back. Level: -63db (1v/bar). Range: 40-8000 cps. 40,000 Ohms. Ask for

**UNIVERSAL "808" VELOCITY MICROPHONE**

UNIVERSAL MICROPHONE CO
Inglewood 1, California

**GRACOIL**

**"One Good Turn – or a Million"**

★ Here, in expanded plant facilities, GRACOIL Coils and Transformers are expertly designed and built to exact specifications. Plan your next product with GRACOILS.

**THE GRAMER COMPANY**

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*Electrical Coils and Transformers*

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**Flexible SHAFTS**

**FLEXIBLE SHAFTS**

that carry power around any corner have many new uses in peace-time developments. Faithful, dependable power drives or remote control in airplanes, automobiles, radio, and many other commercial products.

Shafts made to your specifications. Our engineering department will work out your particular power problem without obligation.

*Write today for Manual D*

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**AMPERITE**

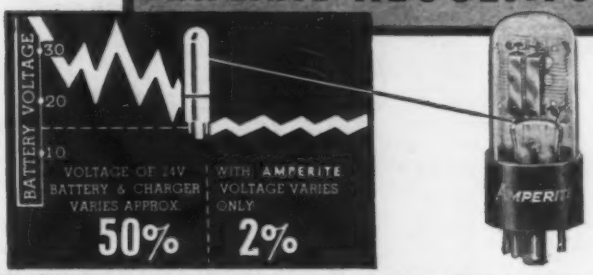
**THERMOSTATIC METAL TYPE DELAY RELAYS**

**PROVIDE DELAYS RANGING FROM 1 TO 120 SECONDS**

**FEATURES:**—Compensated for ambient temperature changes from —40° to 110° F . . . Hermetically sealed; not affected by altitude, moisture or other climate changes . . . Explosion-proof . . . Octal radio base . . . Compact, light, rugged, inexpensive . . . Circuits available: SPST Normally Open; SPST Normally Closed.

**PROBLEM?** *Send for "Special Problem Sheet" and Bulletin.*

**AMPERITE REGULATORS**




Amperite REGULATORS are the simplest, lightest, cheapest, and most compact method of obtaining current or voltage regulation . . . For currents of .060 to 8.0 Amps . . . Hermetically sealed; not affected by altitude, ambient temperature, humidity.

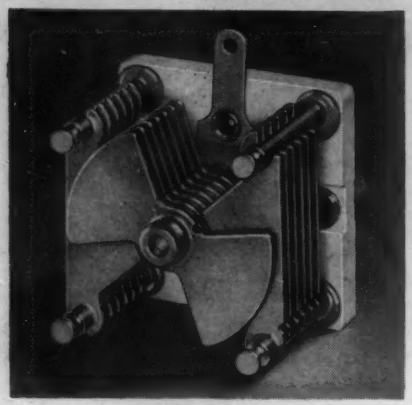
*Write for 4-page Illustrated Bulletin.*

AMPERITE CO., 561 Broadway, New York 12, N. Y.
*In Canada: Atlas Radio Corp., Ltd., 560 King St., W. Toronto*

FOR *Electrical Balance*

**BFC** BUTTERFLY CAPACITORS

BFC-25 ILLUSTRATED



**CONSTRUCTION**

- Soldered rotor and stator assemblies.
- Silver plated rotor contact.
- Sleeve type bearing.
- Low-loss ceramic end panel 1⅜ in. sq., silicone treated.

**SPECIAL FEATURES**

Two methods of use, each with important advantages:

1—Series capacitor, no rotor connection—No rotor contact losses—Low Inductance.

2—Dual, split stator capacitor.—Mechanical and electrical symmetry.—Positive wiping rotor contact.

Isolated studs allow capacitor to be mounted without grounding rotor. Rotor Shaft slotted for screw-driver adjustment.

Rotor maintains setting during moderate vibration because of balanced shape.

**STANDARD SIZES**

| CODE | Cap. Per Sec. in MMFD Max. | Min. | Series Cap. in MMFD Max. | Min. |
|---|---|---|---|---|
| BFC-12 | 14.5 | 3.5 | 7.9 | 2.2 |
| BFC-25 | 27.5 | 5.0 | 14.5 | 3.0 |
| BFC-38 | 40.5 | 6.3 | 21.0 | 3.7 |

Inquiries are invited from manufacturers regarding special capacities and modified designs, where sizeable production will be involved.

THE SIGN OF QUALITY

**HAMMARLUND**

THE HAMMARLUND MFG. CO., INC., 460 W. 34TH ST., NEW YORK 1, N.Y.
MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT

See yourself by television in this corner of the newly opened RCA Exhibition Hall in New York city. Step up on the circular platform, press a button, and the camera boom at the left will make a 120-degree traverse to show all sides of your face as you watch the screen of the television receiver in the plastic dome overhead. Friends can watch repeater screens in the foreground

Street in New York City, opposite the RCA Building. Here visitors can see the history of RCA and NBC depicted in miniature woodcarvings and models, study transparent plastic enlargements of tubes, see themselves on a television screen, see an individual RCA Communications line traced in neon tubing on a huge map when they press a button for a particular city anywhere in the world, and study a host of other unique displays featuring the wonders of modern electronics.

## Microwave Radio Terminal On Pentagon Roof

A SIX-STATION microwave radio relay network extending from the War Department offices in the Pentagon building to the headquarters of the Army Ground Forces at Fort Monroe, Virginia, is now being tested by the Signal Corps.

The equipment was developed by the Bell Telephone Laboratories during the war, and has facilities for eight telephone conversations simultaneously, a maximum of 96 printing telegraph circuits, or a combination of telephone and tele-

**ALLEN**

**Hex-socket screws in numbered sizes**

*extra-dependable*

for electronic devices

Tiny hex-socket Cap Screws and Set Screws steeled to stand amazingly tight set-ups. Cap Screws in the numbered sizes from 1 to 10 inclusive; Set Screws from No. 2 to 10.

The Cap Screws are *Allen "pressur-formd"* for maximum strength of head and socket. This process makes the steel-fibres conform to the shape of the head, — no cut fibres. Threads also formed by pressure-process to a high Class 3 fit, ensuring a high degree of frictional holding-power.

The Set Screws have die-cut threads accurate to a high Class 3 fit, with perfectly-formed hex sockets. The screws can be held on either end of the handy hex keys and turned into the tapped hole without fingering. Allen Hand Drivers are available to facilitate fast assembling.

In radio and television sets, radio telephones, radar equipment, electronic controls, these screws HOLD fine adjustments and intricate assemblies.

*Order of your local Industrial Distributor*

**THE ALLEN MFG. CO.,**
**HARTFORD 1, CONN., U. S. A.**

*Crystals for the Critical*

JK "STABILIZED"

**H15 IS SMALL IN SIZE GREAT IN PERFORMANCE**

Smaller in size than a postage stamp and extremely light in weight, the H15 "Stabilized" Crystal is an outstanding performer. Because of an exclusive JK feature there is no mechanical strain on the leads. Neither does soldering of the leads affect crystal frequency. Can be supplied in a frequency range specified by the customer.

**Write For Folder Or State Your Crystal Problems**

**The JAMES KNIGHTS CO.**
SANDWICH, ILLINOIS

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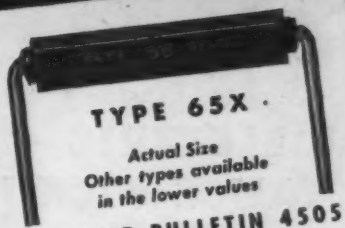
MOLDED
**S.S.White RESISTORS**
*The "All-Weather" Resistors*




Actual Size
Other types available in the lower values

**RESISTOR BULLETIN 4505 GIVES FULL DETAILS . . .**

It shows illustrations of the different types of S. S. White Molded Resistors and gives details about construction, dimensions, etc. A copy, with Price List will be mailed on request. Write for it—today.

- Noiseless in operation
- Strong and durable
- Good performance in all climates

**STANDARD RANGE**
**1000 ohms to 10 megohms**
**• NOISE TESTED •**

At slight additional cost, resistors in the Standard Range are supplied with each resistor noise tested to the following standard: "For the complete audio frequency range, resistor shall have less noise than corresponds to a change of resistance of 1 part in 1,000,000."

**HIGH VALUES**
**15 to 1,000,000 megohms**

**S.S.WHITE INDUSTRIAL DIVISION**
THE S. S. WHITE DENTAL MFG. CO.
DEPT. R, 10 EAST 40th ST., NEW YORK 16, N. Y.
FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED MOISTURE • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

*One of America's AAAA Industrial Enterprises*

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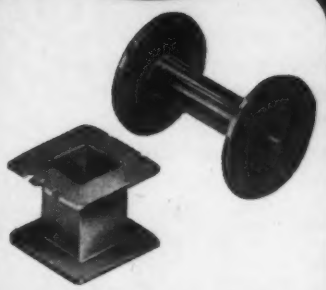
**Molded Phenolic**
COIL FORMS · BOBBINS



**You can save on mold and piece charges at Mayfair**

Coil forms or bobbins, made to your specifications.
Our mold charges are lower than were formerly considered possible.

*Send print for prompt quotation*

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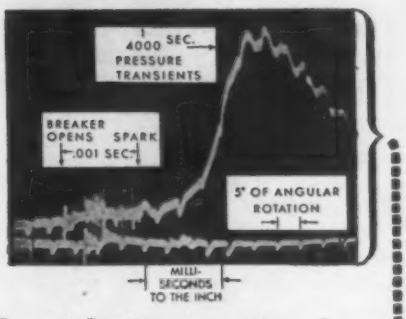
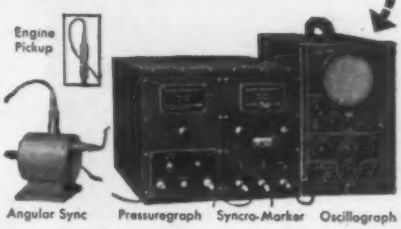
***Have you ever seen the INSIDE of an EXPLOSION?***




*Seeing now made possible by remarkable new electronic features, embodied in*

**PRESSUREGRAPH with Syncro-Marker**

Reproduces on oscillograph screen, accurate picture of pressures during and after explosion, relates pressure variations to time, top dead center, angular velocity, etc. See pressure-time characteristics of automotive, jet and Diesel engines, also compressors, pumps, etc. Operates over range from static up to 10,000 cycles at pressures from 0 to 10,000 lbs.




***Send for description and full engineering data.***

**ELECTRO PRODUCTS LABORATORIES**
**549 W. Randolph St., Chicago 6, Ill.** **Phone ST ate 7444**

# THE GENERAL ELECTRIC VARIABLE RELUCTANCE PICKUP

RECORD enthusiasts are critical customers—whether they be devotees of Bach or boogie-woogie. Better and better reproduction of their favorite recordings is an insistent demand that must be met.

The General Electric Variable Reluctance Pickup can help you to meet that demand. It will appeal immediately to the technical mind due to its simplicity and direct resolution of difficulties often associated with phonograph pickups.

Check this list of major features:

- Low Needle Talk
- Negligible needle scratch
- Low Distortion
- Permanent sapphire stylus
- Minimum record wear
- Frequency response 30-10000 cycles
- Not affected by adverse climatic conditions

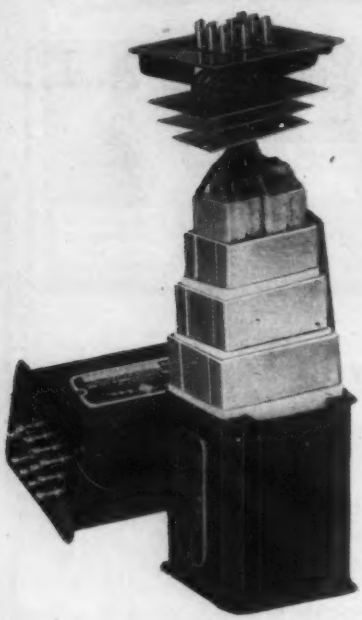
For complete information write to:
*General Electric Company, Electronics Department, Syracuse 1, N.Y.*

GENERAL ELECTRIC

168-P1

# FOR LOW HUM.. HIGH FIDELITY

SPECIFY KENYON TELESCOPIC SHIELDED HUMBUCKING TRANSFORMERS



For low hum and high fidelity Kenyon telescoping shield transformers practically eliminate hum pick-up wherever high quality sound applications are required.

CHECK THESE ADVANTAGES

- LOW HUM PICK-UP . . . Assures high gain with minimum hum in high fidelity systems.
- HIGH FIDELITY . . . Frequency response flat within ± 1 db from 30 to 20,000 cycles.
- DIFFERENT HUM RATIOS . . . Degrees of hum reduction with P-200 series ranges from 50 db to 90 db below input level . . . made possible by unique humbuckling coil construction plus multiple high efficiency electromagnetic shields.
- QUALITY DESIGN . . . Electrostatic shielding between windings.
- WIDE INPUT IMPEDENCE MATCHING RANGE.
- EXCELLENT OVERALL PERFORMANCE . . . Rugged construction, lightweight - mounts on either end.
- SAVES TIME . . . In design . . . in trouble shooting . . . in production.

Our standard line will save you time and money. Send for our catalog for complete technical data on specific types.

For any iron cored component problems that are off the beaten track, consult with our engineering department. No obligation, of course.

KENYON TRANSFORMER CO., Inc.
840 BARRY STREET NEW YORK, U. S. A.




graph circuits. The operating frequency is close to 5,000 mc. Any of the stations can be dismantled, moved to another site miles away, and placed in operation again in a matter of hours, as required to keep pace with the moves of major headquarters in highly mobile warfare.

## Radio Conference

MEMBERSHIP of the United States delegation to the International Radio Conference which began May 15 at Atlantic City, New Jersey, is as follows:

*Chairman:* Charles R. Denny, Chairman, FCC.

*Vice-Chairman:* Francis Colt deWolf, Chief, Telecommunications Division, Department of State.

*Delegates:* Gordon L. Caswell, Captain, U.S.N., Fleet Operations, Communications Officer, Navy Department.

J. Howard Dellinger, Chief, Central Radio Propagation Laboratory, Division 14, National Bureau of Standards, Department of Commerce.

Ewell K. Jett, Commissioner, FCC.

Donald E. McKay, Captain, U.S.C.G., Chief, Communications Division, United States Coast Guard, Treasury Department.

Paul D. Miles, Chief, Frequency Service-Allocation Division, FCC.

Harvey B. Otterman, Assistant Chief, Telecommunications Division, Department of State.

A. G. Simson, Consultant, Communications Liaison Branch, Office of the Chief Signal Officer, War Department.

Edward M. Webster, Commissioner, FCC.

*Consultants:* Spencer B. Akin, Major General, U.S.A., Chief Signal Officer, United States Army, War Department.

Harold M. McClelland, Major General, U.S.A., Commanding General, Airways and Air Communications Service, War Department.

Earl E. Stone, Rear Admiral, U.S.N., Director of Naval Communications, Navy Department.

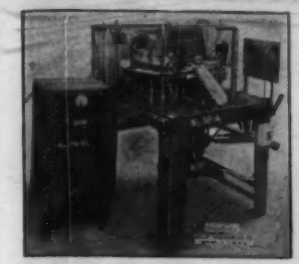
In addition, there are over 20 advisers from various government departments, along with representatives of private telecommunications operating companies who have been certified as part of the delegation in an advisory capacity.

The second of the series of three conferences scheduled for this summer, the International Telecommunications Plenipotentiary Conference, convenes July 1 at Atlantic City. The International High Frequency Broadcasting Conference meets immediately after the close of the second conference.

## Harvard Laboratory Renamed

HARVARD University's research laboratory in physics will be called the Lyman Laboratory of Physics after

EISLER
**ELECTRICAL & ELECTRONIC EQUIPMENT**
**ELECTRONIC TUBE EQUIPMENT**



24 HEAD RADIO TUBE EXHAUSTING MACHINE

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We Make Complete Equipment For The Manufacture Of Incandescent Lamps Radio and Electronic Tubes.

**TRANSFORMERS OF ALL TYPES**

For LIGHTING POWER FURNACES PHASE CHANGING DISTRIBUTION ETC.

●

Air, Oil, or Water Cooled

Sizes ¼ To 250 KVA

**SPOT WELDERS**
OF ALL TYPES
FOR ALL PURPOSES
SIZES ¼ to 250 KVA
Butt Welders - Gun Welders
Arc Welders
Neon Sign Units
Fluorescent Tube
Manufacturing Equipment

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**EISLER ENGINEERING CO., INC.**
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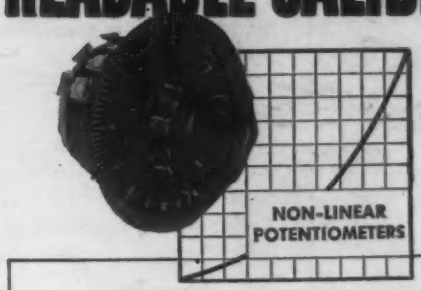
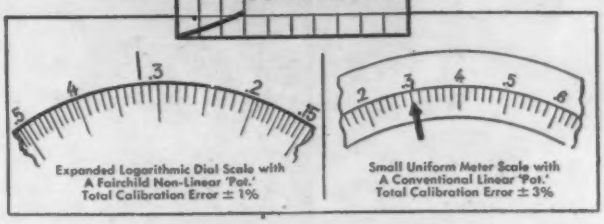
# READABLE CALIBRATION




at CRITICAL CONTROL POINTS


Expanded Logarithmic Dial Scale with A Fairchild Non-Linear 'Pot.' Total Calibration Error ± 1%
Small Uniform Meter Scale with A Conventional Linear 'Pot.' Total Calibration Error ± 3%

Study the calibration sketches shown above. They illustrate how a precision Fairchild non-linear potentiometer—*which permitted the uniform scale to be arbitrarily expanded into a logarithmic dial that provided a more readable calibration control at critical points*—successfully replaced a less accurate linear potentiometer and a difficult-to-read meter. The change-over to a Fairchild non-linear potentiometer tripled the accuracy of control, eliminated a meter and provided greater reliability under severe operating conditions. For data address: Dept. D, 88-06 Van Wyck Blvd., Jamaica 1, N. Y.

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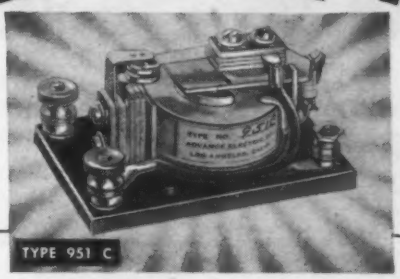


**The Advance type 951 C** is a heavy duty SPST relay. Its ⅜" pure silver contacts are rated at 20 Amps., 110 V.A.C. for non-inductive loads...ideal for use in motor controls where high starting currents cause special problems.

For applications in which higher currents must be handled, the Advance type 961 C may be used. This relay is similar to the one illustrated above, except that it has two sets of ⅜" pure silver contacts banded together...rated at 30 Amps., 110 V.A.C. non-inductive.

**Both relays are built for heavy duty, dependable, trouble-free service...coil voltages up to 230 V.D.C. and up to 440 V.A.C.**

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Advance Relays

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**1260 West 2nd St., Los Angeles, California • Phone Michigan 9331**

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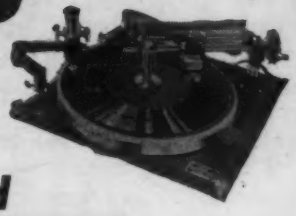

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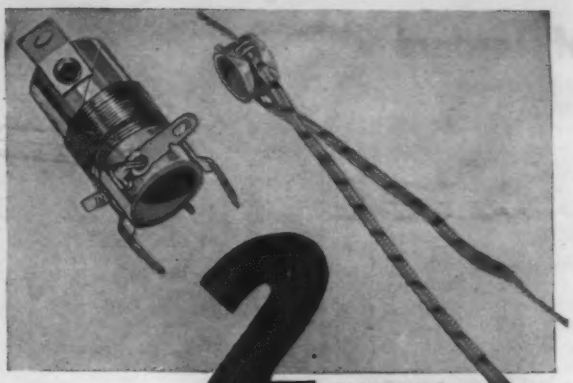

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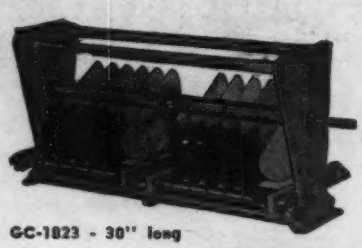
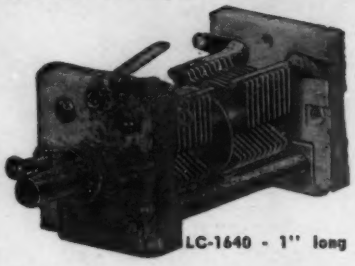


GC-1823 - 30" long



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See your local distributor for information on the complete BUD condenser line. Ask him to show you the many differences that make this line so perfect for your use.

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June 30 in honor of Prof. Theodore Lyman, retiring director who has held this post since 1910. Prof. Lyman is internationally known for his researches in ultraviolet spectroscopy, the Bohr quantum theory of line spectra, and improved vacuum techniques. He is a past president of the American Academy of Arts and Sciences and of the American Physical Society, and holds the Rumford, Elliott Cresson, and Frederick Ives medals. His successor will be Dr. Roger W. Hickman.

## Navy Science Training

APPROXIMATELY 800 Navy scientists and technicians in the Washington, D. C. area will study for advanced academic degrees this fall while continuing their government work. This will be a 100-percent increase over the Navy's 1945-46 science training program, when approximately 400 scientists enrolled in 20 courses.

Navy officials point out that such graduate study improves the performance and professional competence of personnel engaged in scientific and technical work, and at the same time is an important factor in attracting high-grade personnel.

## D-F for Lost Pilots

THREE U. S. radio direction-finding networks are available to help lost civilian fliers. Largest is that of the FCC, which has ten primary d-f stations on a teletype hookup and seven others in a radio network, all ready to concentrate immediately on any transmission between 2 and 20 mc from an aircraft in distress. This network handles an average of 11 lost-aircraft emergency calls every month.

The Coast Guard has four d-f stations equipped to take bearings over the same frequency range as the FCC stations, and in addition maintains a continuous listening watch on the 8,280-kc emergency frequency.

Recently the Army offered use of its 19 vhf d-f stations in the United States to civilian fliers, for giving bearings on transmissions between


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Offering complete insulation . . . current capacity of 30 amperes . . . working voltage of 1000 volts; the new Superior Binding Post type DF30 meets the need for a multi-purpose electrical connector.

*Features Five Connections*

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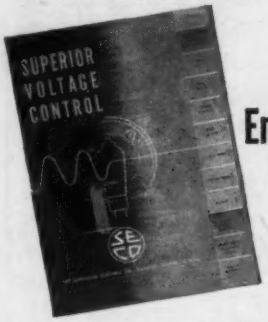
4. Clip-lead by removing the hexagonal shaped phenolic head.
5. Spade lug connection.

*DESCRIPTIVE LITERATURE ON REQUEST*

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(which tells how much power must be used to transmit a particular frequency over a particular distance), and the heights of the various layers (which is accomplished through the use of radar-like echo equipment).

Groups now using the Bureau's sunspot prediction service include domestic and overseas airlines, steamship lines and the merchant marine, television and radio schools, universities, libraries, radio and telegraph companies, manufacturers of communication equipment, consulting radio engineers, press wireless and telegraph services, broadcasting companies, industrial electrical firms, navigation instrument companies, research laboratories, electric power companies, and geophysical exploration organizations.

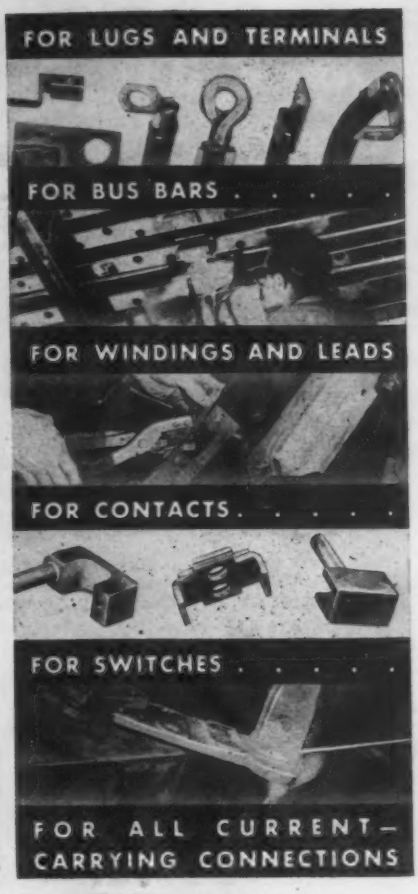
In the Federal Government the Army and Navy are the main users; others are the Weather Bureau, State Department, FCC, CAA, Immigration and Naturalization Service, Forest Service Radio Laboratory, and Coordinator of Inter-American Affairs.

## FCC Changes Regulations Governing Aeronautical Radio

NEW RULES and regulations governing aeronautical radio, comprising Part 9 of the FCC setup, became effective May 1. In effect, these changes constitute a revamping of Aeronautical Radiocommunication Service to accommodate aviation's postwar developments and meet current needs of industry, government, and private interests.

Next to the amateur service, the aviation service now constitutes the largest single radio group licensed by the Commission. At the present time there are nearly 15,000 aviation stations, of which nearly 13,000 are aircraft and the remainder are ground facilities.

To meet a growing demand for radio communication in flying instruction, the FCC has authorized the Flying School class of station. Flying School stations may also be used by soaring societies in connection with motorless flight activities. To facilitate testing of aircraft, fre-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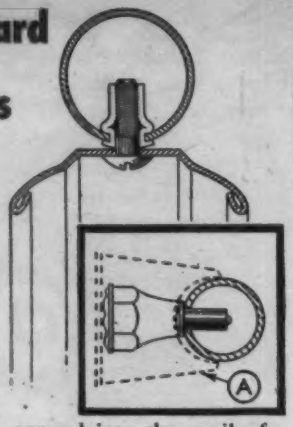
## NEW USE of standard RIVNUT licks tough fastening problem . . .




Designs for a new bicycle required a blind fastener which would serve as a nutplate for attaching a mudguard to the tubular frame. The head of the rivet had to conform to the curvature of the tubing. A *standard* flat head Rivnut solved the problem.

First, the correct radius was ground into the anvil of a standard heading tool. Guide "A" was added to insure correct curvature. The heading tool then formed the ring-shaped bulge and curved head of the Rivnut at the same time! With its threads still intact, the Rivnut now provided a deeply-threaded nut plate for the mudguard attachment.

Perhaps Rivnuts will simplify your fastenings, reduce your costs. Why not consult a B. F. Goodrich Rivnut engineer?

**AUTHORITATIVE LOAD CAPACITIES IN NEW "RIVNUT DATA BOOK"**

Eccentric, tension, single and double shear load capacities of various Rivnuts are listed in the new, 40-page edition. Types, sizes and uses are also given. Fully illustrated, including step-by-step drawings of Rivnut installation. Write for your copy to

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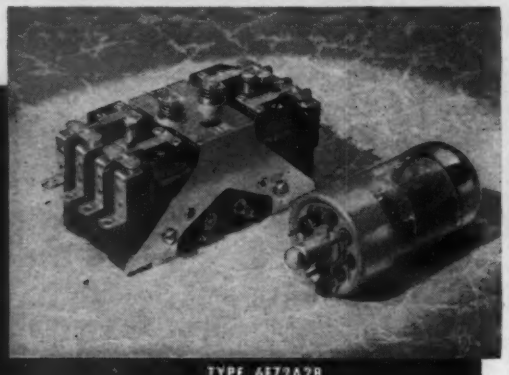


*A substantial improvement over existing types of mechanical latch electrical reset relays.*

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- 8 separate contact positions available in any combination of Normally Open or Normally Closed circuits (Two N.O., Two N.C., — double break shown above.)
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**OTHER NEW SIGMA RELAYS**

- Multicontact sensitive relays, A.C. and D.C.
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120 and 140.58 mc. The latter frequency has been approved for emergency GCA use by civilian planes.

A pilot requiring direction-finding assistance need only notify any available CAA facility of his difficulty, giving a list of frequencies on which he is equipped to transmit. After direction-finding personnel have been alerted, he will be told which frequency to use for a long call comprising five minutes or more of steady radio transmission with repeated identification calls. After a fix or bearing is obtained, the pilot will be given a course to fly to the nearest suitable landing field.

•

### Sunspot Predicting Service

A NEWLY developed method for predicting sunspots affecting radio communication has been developed by scientists at the National Bureau of Standards in connection with its program for forecasting radio weather three months in advance. These predictions enable radio engineers to calculate the best usable frequencies for communication between any two points in the world for any hour of the day.

The method of prediction utilizes available information on previous eleven-year sunspot cycles. No two cycles are ever exactly alike but an average cycle can be determined. The next step is to average the deviations of various parts of each cycle from the average or ideal cycle, to obtain a correction factor which is then applied to predictions of future values in the present cycle.

The basic information on annual sunspot numbers is obtained from the Zurich, Switzerland, Observatory which has been maintaining continuous records on all types of solar activity since 1849. In addition to this, daily soundings of the ionosphere occur all over the world at the international network of 58 ionosphere stations, which include 7 Bureau field installations, cooperating universities, and foreign research institutions. These daily soundings measure the critical frequencies (the highest frequency that will be reflected back to the earth), absorption of radio energy

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**BRACH PURATONE* SIGNAL BOOSTER**

**CARRIES AM, FM and TV ANTENNAS ALL ON THE SAME MAST**

Increase your radio sales by bringing home-like reception to any AM, FM and TV set in your showroom . . . eliminating all interference and bothersome noises.

**HERE'S HOW:** The Puratone Signal Booster System is easily installed on the roof of your building. A shielded coaxial cable runs directly from the mast to the concealed amplifier on the display floor.

From the amplifier a radiating wire is placed inconspicuously around the display space. No direct wire connection to radio sets required. One system serves any number of floor models. Dual wave traps in the video-type AM-FM amplifier bring in all stations at an average tone-level. 30-40 DB gain on FM; 40-60 DB gain on AM. Effective for any radio department layout.

Write for illustrated circular.

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THROUGH
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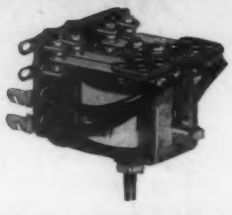

*LEACH MIDGET SERIES for SPACE ECONOMY in MODERN DESIGN*

Leach Midget Relays meet today's demand for compact design—and assure positive, dependable control. The Midget Series offers a wide choice of types, each so tiny it weighs less than two ounces and all measure less than two inches.

When you hold a Leach Midget Relay, between just two fingers, you can readily *see* the evidence of manufacturing skill and Electrical-Engineering design that's typically *Leach*. Here, quality materials and careful workmanship challenge comparison. The term "Mighty Midgets" is aptly suited to Leach Midget Relays.

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quencies have also been allocated for the Flight Test Station.

In common effort with the CAA, frequencies are available for collecting operational data as to the value and needs of new radio systems proposed for control and navigation of aircraft.

Because there are not enough frequencies for airlines individually and exclusively, the Commission requires a licensee of any aeronautical facility to render service without discrimination to all airmen.

For private communication between individuals aboard planes in flight and persons on the ground, the Public Service type of station is provided. By use of a Public Service station, persons in aircraft may be connected to the nationwide land-line telephone system. Public Service aircraft stations on transport planes engaged in intercontinental service have been authorized to operate experimentally on the frequencies available to ship-telephone and ship-telegraph stations, to determine the feasibility of handling communications in the same manner as vessels offering public service. Should this prove successful, aircraft flying transoceanic routes will be in the same category as ocean-going ships.

## *MEETINGS*

AUG. 26-29: AIEE 1947 Pacific General Meeting, Hotel San Diego, San Diego, Calif.

SEPT. 8-12: Second Annual Conference and Exhibit of The Instrument Society of America, at Stevens Hotel, Chicago.

SEPT. 23-25: AIEE Middle Eastern District Meeting, Dayton, Ohio.

SEPT. 26-28: Hudson Division ARRL Convention, Convention Hall, Asbury Park, N. J.; technical papers and exhibits of electronic equipment for radio amateurs.

SEPT. 29-OCT. 2: Annual meeting, International Municipal Signal Association, Inc., Pantlind Hotel, Grand Rapids, Michigan; technical papers and exhibits of police and fire radio equipment.

SEPT. 30-OCT. 11: National Radio

Exhibition, Olympia Hall, London, sponsored by British Radio Industry Council and featuring new British radio, electronic control, radar, and television equipment.

Nov. 3-5: National Electronics Conference, Edgewater Beach Hotel, Chicago.

Nov. 3-7: AIEE Midwest General Meeting, Chicago, Ill.

## *BUSINESS NEWS*

MOTOROLA INC. is the new corporate name of the former Galvin Mfg. Corp., Chicago, Ill., manufacturer of home and car radios, aircraft radios, television receivers, and two-way radiotelephone equipment.

LITTON ENGINEERING LABORATORIES has moved into its new 17,000-sq-ft plant on Brittan Avenue in San Carlos, California. The firm's primary function is electron tube design and development. This includes manufacture of special lathes, vacuum pumps, and spot welders for tube manufacturers.

SELENIUM CORPORATION of America is now occupying its new and modern structure in El Segundo, Cali-

**New selenium rectifier and photocell plant**

fornia, having 32,000 sq ft of floor space.

RAYTHEON MFG. CO. has produced for Compania Radiografica Internacional de Costa Rica the first microwave radio communication equipment to be installed in Central America, operating on 4,000 mc with 50-watt c-w type magnetrons and carrying multiplexed telegraph and telephone channels operating simultaneously.

AMERICAN MICROPHONE CO., formerly of Los Angeles, is now making microphones and phono pickups in its new $100,000 plant providing 20,000 sq ft of floor space in Pasadena.

CANADIAN-ADMIRAL CORP. Ltd. has

• Amphenol, originator and long-time producer of extruded polyethylene insulated Twin-Lead for transmitting and receiving, now announces an important improvement.

At no increase in price, the dielectric insulation has been changed to solid brown Amphenol Ethylon-A containing an anti-oxidant. This new insulation is equal to the old in low loss properties. It is far superior in resistance to the effects of sunlight and moisture.

Preferred by amateurs for antennas and transmission lines, Twin-Lead transmits signals with minimum loss, is durable and inexpensive. The Ethylon-A dielectric is full thickness edge to edge, minimizing impedance changes caused by moisture collecting on the surface. Amphenol Twin-Lead is unaffected by acids, alkalies and oils. Flexibility remains unimpaired at temperature down to —70°F.

The new *brown* Amphenol Twin-Lead is available in 75 ohm, 150 ohm and 300 ohm impedances for receiving use, and in 75 ohm type for transmitting. Write today for full data on electrical characteristics and prices.

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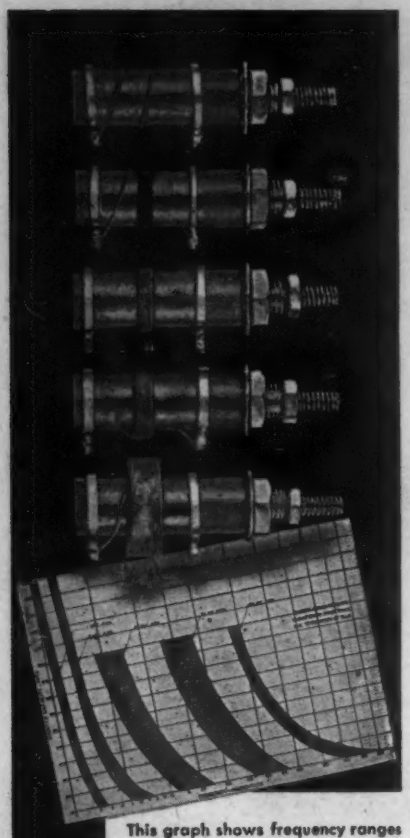

This graph shows frequency ranges covered by each unit. Write us for your full-size copy.

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Split Lug

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Swager

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**Five Standard Slug-Tuned LS3 Coils Cover ½ to 184 mc**

For strip amplifier work, the compact (1¼" high when mounted) LS3 Coil is ideal. Also for Filters, Oscillators, Wave-Traps or any purpose where an adjustable inductance is desired.

**Five Standard Windings**—1, 5, 10, 30 and 60 megacycle coils cover inductance ranges between 750 and 0.065 microhenries.

CTC LS3 Coils are easy to assemble, one ¼" hole is all you need. Each unit is durably varnished and supplied with required mounting hardware.

**SPECIAL COILS**

CTC will custom-engineer and produce coils of almost any size and style of winding... to the most particular manufacturer's specifications.

*Consult CTC for Three-Way Component Service*

Custom Engineering... Standardized Designs...
Guaranteed Materials and Workmanship
CAMBRIDGE THERMIONIC CORPORATION
437 Concord Avenue, Cambridge 38, Mass.


NEWS OF THE INDUSTRY (continued)

leased space in Long Branch, Ontario for the manufacture of Admiral radios in Canada.

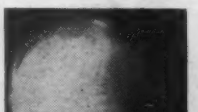
CORNING GLASS WORKS is adding to its Charleroi, Pa. plant two new buildings to provide additional melting capacity and general floor space for enlargement of their television bulb program. Face diameters will range from 7 to 15 inches.

ST. LOUIS MICROPHONE CO., which recently moved into a new building in St. Louis, Missouri, is now incorporated under the laws of the State of Missouri.

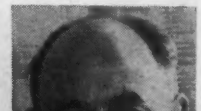
SOUND APPARATUS CO., with main offices in New York City, has opened its new plant in Stirling, N. J. for the production of graphic level recorders for acoustical and electrical measurements. The company's research laboratories are in Millington, N. J.

## *PERSONNEL*

STANLEY BRACKEN, who joined Western Electric Co. immediately after graduation in 1912, has been appointed executive vice-president, replacing William F. Hosford who retired after nearly 41 years of service with the company.



S. Bracken



E. Fermi

ENRICO FERMI, physicist at the Nuclear Research Institute in Chicago, was awarded the 1947 Franklin Medal, highest honor of The Franklin Institute, for his outstanding work in the field of atomic energy.

J. MONTAGUE BRIDGEMAN now is manager of the electronics division of Photographic Survey Co., Ltd., Toronto, Canada, in charge of operation and development of electronic aids to aerial survey and exploration. He was formerly director of electronic development at

CONSTANT-IMPEDANCE Controls

★ **The Clarostat Series CIB Attenuator (shown) was developed to meet the need for a constant-impedance attenuator capable of handling considerable power with low insertion loss. Provides linear attenuation with ample power-handling capacity.**

Recommended as output level control for power amplifiers, or as input attenuator for individual loudspeakers in P-A system.

Dissipates 10 watts at any setting. Linear up to 30 db. in 10 steps, beginning with absolute zero and progressing in 3 db. steps up to 24, and then 30, followed by infinity.

Available in several ohmages to meet all requirements. Fibre-glass resistance elements. Single-hole mounting. Only 2¾" long by 2" diameter.

★ **DATA on request . . .**

Write for Bulletin 111 on Series CIB Attenuator. If interested in L-pads and T-pads, ask for Bulletin 102, as well.

CLAROSTAT Controls and Resistors

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

Royal Canadian Air Force headquarters in Ottawa.

JULES J. BRESSLER, at one time chief engineer of Beltone Sound Systems Co., has recently been appointed field sales engineer of Atlas Sound Corporation.

C. P. Cushway

H. C. Ingles

CHARLES P. CUSHWAY has been elected executive vice-president and a director of Webster-Chicago Corporation.

HARRY C. INGLES, who as Major General and Chief Signal Officer of the U. S. Army from July 1943 to March 1947 was responsible for the Army's world-wide communications system, has been elected president and a director of the RCA Institutes, Inc.

WILBUR F. CLANCY has been promoted to assistant transmitter supervisor of station WTIC, Hartford, Conn.

HARRY F. MICKEL, formerly manager of RCA's Communications Equipment Section, recently joined the Radio Engineering Products Division of Raymond Rosen & Co. as engineering sales manager.

IRA KAMEN, formerly director of electronics for Conlan Electric Corp., is now manager of the sales and installation division of Intra-Video Corporation of America, New York, N. Y., and will supervise installation of new master antenna systems for television.

JOSEPH H. GILLIES, Philco vice-president in charge of radio production, was elected to the board of directors of Philco Corp., Philadelphia.

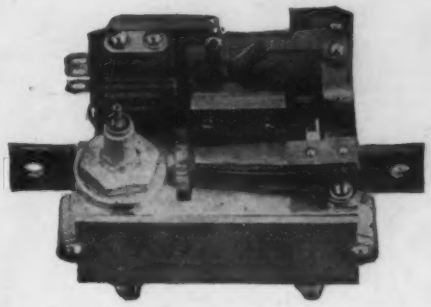
H. H. BEVERAGE, director of radio systems research at RCA Laboratories, was elected first vice-president of the New York Electrical Society for the 1947-1948 term.


# COAXIAL CABLE RELAYS

for high frequency switching

Two Sizes: 50 Watt and 250 Watt Capacity

—standard coil operating voltages AC or DC.



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*Write for Descriptive Literature CE6*

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This low-cost, easily applied material helps to eliminate hum and sound interference . . . acts as a squeak-proof gasket when applied to adjoining wood or metal surfaces . . . forms a nonsagging, attractive speaker panel when sprayed on common mesh screen.

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CP Cellusuede Products, Inc.

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**SOLDERING GUN**

**5-SECOND HEATING**
Ready to solder in 5 seconds.

**LESS TIP RETINNING**
Heats only when needed.

**FAST COOLING**
Ideal for service calls.

100 Watts
115 Volts
60 Cycles

• You get fast, dependable soldering heat because the Weller Soldering Gun operates on a new principle. A specially engineered built-in transformer of light weight produces soldering heat in the loop tip. See your radio parts distributor or write for bulletin.

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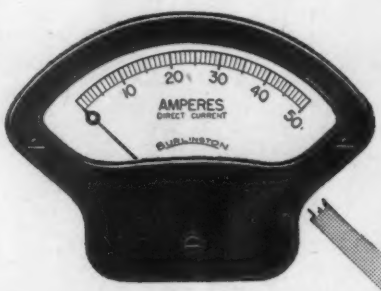
Export Dept.: 25 Warren St., New York 7, N. Y.

• *RUGGED*
• *DEPENDABLE*
• *ACCURATE*

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For utmost reliability — specify and depend upon Burlington Panel Instruments. They are designed, engineered and built to give satisfactory service even under most severe applications — and are fully guaranteed for one year against defects in material or workmanship.

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# NEW BOOKS

## Radar Engineering

By DONALD G. FINK, *Editor*, ELECTRONICS. *McGraw-Hill Book Company, Inc., New York* 18, *New York*, 1947, 644 *pages*, $7.00.

HERE IS a book which represents a substantial step forward in bridging the gap between wartime secrets and engineering and educational requirements of a peacetime world. The author, drawing heavily upon past connections with the MIT Radiation Laboratory, various assignments as an expert consultant for the Office of the Secretary of War, and experiences with the Joint Army-Navy Task Force at Bikini, has admirably succeeded in reducing the rather complex subject of radar to straightforward engineering reading. Throughout all 12 chapters, the reader is continually conscious that the writer is qualified in the subject as an engineer and has excellent talent for exposition and to-the-point explanation of difficult subjects.

By way of introduction to the subject, an excellent history of radar is given starting with Maxwell and Hertz and particularly pointing out the early work of the Service laboratories and the British in this field. The book is not highly mathematical, although an understanding of calculus and harmonic functions will be of considerable assistance to the reader, particularly in the first half of the book which deals with radar fundamentals. The second half is more descriptive than mathematical, and is generally devoted to illustrations of various types of radar gear developed during the war. Chapter titles include: Introduction to Radar Concepts; Principles of Pulse Generation and Transmission; Transmission Lines, Waveguides, and Resonant Cavities; Radiators and Reflectors, Propagation, and Targets; Introduction to Radar Design; Basic Pulse Circuits; Basic Radio-frequency Circuits and Structures; Synchronization Equipment (Timers); Transmitters and Radiators; Receivers; Indicators and Scanners; Radio-frequency Measurements and Test Equipment.

The reviewer considers the two

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## COPPER OXIDE RECTIFIERS

### INSTRUMENT RECTIFIERS FOR BETTER A. C. SCALE

Vacuum-processed, gold-coated, full-wave bridge, Bradley instrument rectifiers allow more accurate determination of very low A.C. current. Especially designed for use where stability and permanence of calibration are important, "Coprox" rectifiers meet the most exacting requirements. Yet they cost no more than ordinary rectifiers — in most cases, less.

Temperature error is exceptionally low with Bradley rectifiers. Aging is practically nil. Shown above, CX2E4F rated up to 4.5 volts A.C., 3 volts and 5 milliamperes D.C.

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*Cyclohm* | **SYNCHRONOUS CAPACITOR TYPE MOTOR**

THIS new Cyclohm 29 size has no equal as a synchronous, capacitor type motor for recording, tape pulling, facsimile work and other jobs which require a *quiet, smooth, vibrationless motor.* Internal rotor slots permit a higher starting torque and a quieter performance. Substantial cap seats, turned in the frame and end caps, ensure perfect rigidity, accurate bearing alignment, uniform air gap, and a vibration-free motor. Supplied with either ball bearings or sleeve bearings—in ratings of 1/100, 1/75 and 1/50 horsepower, 1800 r.p.m., 115 volts, 60 cycles. Write for complete information.

**CYCLOHM MOTOR CORPORATION**

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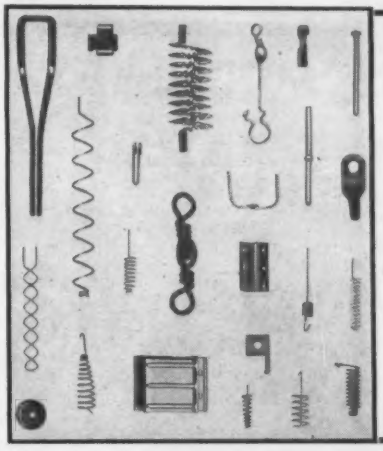

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Filaments, anodes, supports, springs, etc. for electronic tubes. Small wire and flat metal formed parts to your prints for your assemblies. Double pointed pins. Wire straightened and cut diameter up to ⅛-inch.. Any length up to 12 feet.

LUXON fishing tackle accessories.

Inquiries will receive prompt attention.

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*Quality Tools* **PREFERRED BY EXPERTS**

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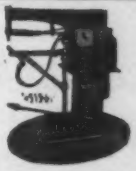

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*This* CONTACTS *Section*

supplements other advertising in this issue with these additional announcements of products essential to efficient and economical operation and maintenance. Make a habit of checking this page, each issue.

Classified Advertising Division

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*— For "Parts" Marking —*
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High Speed Production Of Quality R. F. Coils and Sub-Assemblies, For Discriminating Manufacturers

Clippard INSTRUMENT LABORATORY, INC.
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Solve Wire Stripping Problems with "SPEEDEX"

WIRE STRIPPER KIT

The famous "Speedex" Wire Stripper complete with 7 interchangeable blades for stripping any size wire from No. 8 to No. 30 will be the handiest tool in the shop. Strips 800 to 1000 wires per hour—cuts wires too. Just press the handle and the job is done. For use with solid or stranded wires. Write today for catalog of 3,000 electronic products.

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Prompt Deliveries

Specializing In High Voltage Filament and Plant Transformers for Electronic Projects

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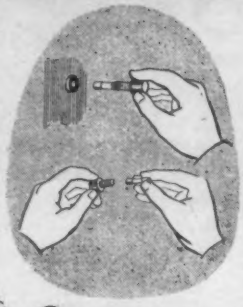
Safe, "dead front" Littelfuse Extractor Fuse Mounting Posts are easy to install. They save panel space—can be ganged in rows with a common bus.

Fuse holder is in end of removable knob—unscrew it and fuse is quickly extracted and changed with fingers.

Finger and screwdriver operated types in 3AG and 4AG sizes now are available.

Catalog number 9 gives you complete details, write for yours today.



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**The complete frequency characteristics at a glance on your present oscillograph!**

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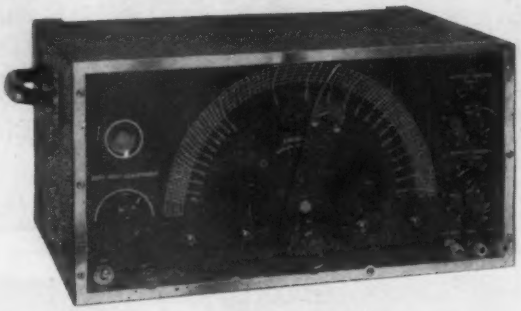
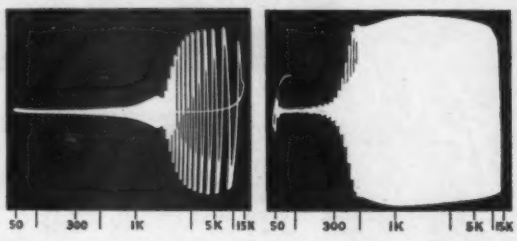


*Dividing speaker network with 400C. crossover.*




CB

**The CLOUGH BRENGLE CO.**
**6014 Broadway Chicago 40, Ill.**




chapters devoted to radio-frequency fundamentals the best easy-reading presentation he has yet seen on the subject, for in these chapters the author lucidly establishes a strong linkage between prewar radio engineering and the war-developed field of microwaves.

By way of general criticism, it is unfortunate that most of the references are to Army equipment rather than an equal balance between Army and Navy. As the author understandably points out, this discrimination was unavoidable since during the preparation of the book the Navy had not yet declassified several comparable equipments. This does not seriously detract from the book, however, since specific references are introduced chiefly to bring out principles of engineering practice and design which for the most part are common to the equipments of all the Services.

Because of the wealth of information contained therein, representing both collected works and information revealed for the first time, this book should be very useful to anyone studying, teaching, or engaged in engineering practices dealing with radar or radio.

—HAROLD A. ZAHL

### German Research in World War II

By LESLIE E. SIMON, *director, Ballistic Research Laboratories, Aberdeen Proving Ground. John Wiley & Sons, Inc., New York,* 1947, 218 *pages,* $4.00.

GENERALIZATION of a 200-page government technical report by scientists who examined German technical establishments immediately after their capture. Important projects are summarized, with highly interesting photographs of new equipment that received little or no field use.

References to electronic equipment, generally brief and lacking technical details, include a radio Doppler system for measuring and controlling V-2 projectile velocity, electronic chronographs, piezoelectric pressure gages for cannon, and infrared detectors and night lights. A concluding chapter gives recommendations for fostering long-term scientific research.—J.M.

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*NEW ADVERTISEMENTS received by 10 A. M. July 3rd will appear in the August issue, subject to limitation of space available.*

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Combines an acute cost consciousness with full appreciation of consumer demands. Capable of developing a complete AM, FM line for high-speed profitable production and public acceptance.
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PW-348, Electronics
330 West 42nd St., New York 18, N. Y.

### EMPLOYMENT SERVICES

(Continued from opposite page)

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COOPER UNION Scholarship student, ranking third, desires summer position, electrical engineering, in or around New York City. Call President 2-5957 after 5 P.M.

TELEVISION DEVELOPMENT engineer experienced in design of relay links studio and field equipment desires position as chief engineer of television station. PW-352, Electronics, 330 W. 42nd St., New York 18, N. Y.

### CONTRACT WORK

PROGRESSIVE FIRM of United Kingdom manufacturers able undertake repetition and light assembly work, with specialized knowledge in electrical instruments, radio and electronic fields, seek a sound tried-out line for exclusive manufacture in the United Kingdom. Director of the firm is due in the U. S. between May 20th and June 30th, and will be ready to investigate any interesting proposition on the spot. CW-353, Electronics, 330 W. 42nd St., New York 18, N. Y.

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Formerly Vice President & Chief Engineer thousand employee company manufacturing complete radar equipment.
Desires connection medium to small concern penetrating the industrial electronics control and inspection field. Salary range $10,000. Immediately available.

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We are looking far ahead today in the field of quality of radio communications and other electronic equipment. Our plans, well advanced, offer substantial opportunity for mechanical design engineers in a field of interest, research and development. Cedar Rapids is a human, wholesome city. People enjoy living here and working in our modern plant, which is neither small nor large, but rather ideal.

If you feel qualified for one of these positions, write us fully, stating age, education and experience, as well as other pertinent data you feel might assist us in fully and promptly considering your application. All replies will be held strictly confidential. Apply to

**COLLINS RADIO COMPANY**

CEDAR RAPIDS IOWA

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## COMMUNICATIONS ENGINEER OR PHYSICIST

The National Geophysical Company, Inc. has an opening on its Engineering staff for a communications engineer, or physicist with electronic training, who is interested in research and development. Projects cover all phases of geophysical work. This position is permanent. Salary open. For additional details address

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FLushing 3-8807

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Experienced senior electrical and mechanical project engineers needed for responsible positions in development and production of A.M., F.M., television receivers and components. Opportunity for advancement. State qualifications in application to:

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Experienced in microwaves and/or radar, for established research and development laboratory. Excellent opportunities. Write:

P-354, Electronics
330 West 42nd St., New York 18, N. Y.

ADDITIONAL SELLING OPPORTUNITY AD ON PAGE 264

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EXCEPTIONAL FACILITIES
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SPECIAL PATENT SITUATIONS
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put the solution of your problems up to a specialized Consultant whose professional card appears on this page. His broad experience may save you months of costly experimentation.
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**Eugene Mittelmann, E.E., Ph.D.**
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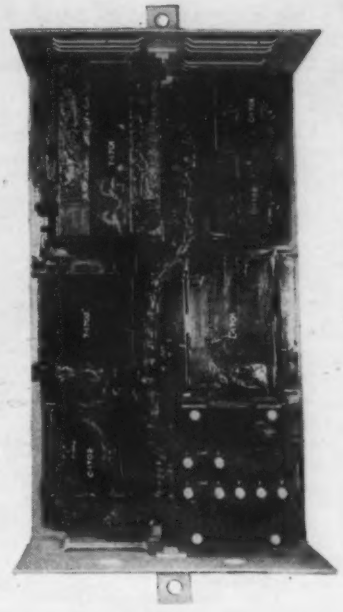
## General Electric



Cat. #69 G 30152 Type #CG 301252.

**INPUT** from 103 to 127 volts at 57 to 63 c.p.s.

**OUTPUT** voltage taps for 110, 115, 120 & 125 volts. Output voltage under constant load will not vary more than ±1% at normal frequency when the input varies from 103 to 127 volts.

**CAPACITY** 850 Volt Amperes 7.7 amperes at .93 Power Factor.

**DIMENSIONS** 30⅛" H. x 15⅝" W. x 10¼" D. Enclosed in a gray bake enamel steel case. (illus. with cover removed) Ship. wt. 330 lbs. Net wt. 280 lbs.

NET fob, N. Y. **$59.50**

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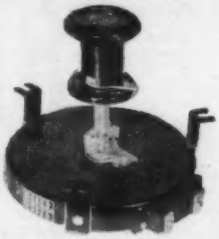
**WARD LEONARD**



20 Ohms 4.05 Amperes 8" Class, complete with handle and all accessories for rear of board mounting. Can also be used for front of board mounting.

800 Units in Stock
Special Prices on Large Quantities

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**PRIMARY**—115 volt 60 cycle

**SECONDARY**—30 volts at 10 Amperes Mfg. by Jefferson Electric Co. Type G.F. Cat #969-001-166. Mounted in Watertight box 110 Units in stock.

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**SECONDARY WINDING**—center tapped 360 volts A.C. at 30 M.A. total. Center tap is brought out directly and also through a 5 Henry series choke.

**DIMENSIONS**—2¼" dia. x 3⅝" overall height

**United Transformer Co.** type #82834.

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# FILAMENT TRANSFORMER

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**INPUT** 110 volt 60 cycle

**OUTPUT** 2.5 volt 40 Ampere. 100 K.V.A., 3 K.V. Insulation
500 in stock

Minimum Order 10 Pieces at **$1.75** Each fob N. Y.

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**Weston**, 301 Type 21 Standard Decibel Meter, 3½", rd fl bake case, —10 to +6, 6 M.W., 600 ohms; General purpose type 0.5—0.7 Second to final reading, 45—62% overthrow, 500 ohms internal resistance at ODB.....$8.50

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**Voltage Polarity Phase Rotation Tester**, Triplett 337 AVP, Checks 115, 200, and 440 line voltage; Locates open circuits, blown fuses, damaged wiring, etc.; Indicates whether A.C. or D.C. and polarity of D.C.; Checks phase rotation to determine direction of rotation of motors, operation of controls, etc.; Consists of a 3" square meter and a small polarized vane movement in a small handy sized case. Complete with 36" leads with test prods.....$8.50

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**W.H.**, NX-35, 200 V, D.C., 200 ohms per volt, mounted on 45° metal angle panel with binding posts.....$4.95

**W.H.**, NX-35, 1.5 KV with 1000 ohms per volt, ext prec wire wound resistor & mtg clips, 3½", rd fl bake case..$6.95

**G.E.**, DO-53, 500 microampere mvt D.C., sc cal 0-15 KV, supp with paper V.O.M.A. sc, 3½", sq fl bake case $4.50

**Triplett**, 100 ua mvt, 950 ohms resist, made for 666-SC Analyzer; sc cal in Volts, MA, and Ohms, 3½", sq fl bake case.....$6.95

**Triumph**, 400 microampere mvt D.C., approx 500 ohms resist, sc cal 0-3, 0-15 and 60 V MA, 4", Rect fl bake case, Knife edge pointer.....$5.50

**W.H.**, NT-33, 250 MA, black sc, sc cal 0-5, mkd "Antennae Current", 2½", rd fl bake case. Radio Frequency Milliammeter.....$3.50

**W.H.**, NT-35, 3 A, R.F., 3½", rd fl bake case.....$5.50

**G.E.**, DW-44, 1 A, R.F., 3½", rd fl bake case.....$3.50

**G.E.**, DW-52, 1.5 A, R.F., black scale, 2½", rd fl metal case.....$2.95

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**Roller Smith**, Type TAS, 8 A, A.C., 3½", rd fl bake case.....$4.50

**All items are Surplus — New — Guaranteed**
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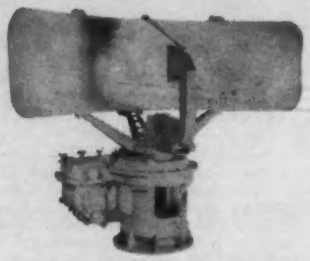

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| **Bulkhead Connector; 4 In. Long.....** | 5.00 |
| **90° Elbow; E Plane; 1½" Radius; 4 In.....** | 5.00 |
| **90° Elbow; H Plane; 1½" Radius; 4 In.....** | 5.00 |
| **90° Twist; 6 Inches Long.....** | 7.00 |
| **45° Twist; 6 Inches Long.....** | 5.00 |
| **Pressurized Unit; 4" Long; Valve & Meter...** | 9.00 |
| **Crystal Mount; Broad-banded; VSWR of 1.1 max. over 8500 to 9400 megacycles.....** | 20.00 |
| **Directional coupler; 21 Db.; 8 In. long Part of AN/CPN-6; Govt. Inspected.....** | 20.00 |
| **Waveguide conn.; Flange; UG-39/U 12 for** | 5.00 |
| **Waveguide conn.; Choke; UG-40/U 12 for** | 7.00 |
| **Waveguide conn.; UG-51/U; Flange.....** | .75 |
| **Waveguide conn.; UG-52/U; Choke.....** | 1.00 |
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| **Waveguide; RG-52/U; ⅛"x1; 10 ft. lengths; per foot .....** | .50 |
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| **Connectors; UG-21; UG-22; UG-24; UG-27; UG-30; UG-58; UG-105; UG-102; each...** | .75 |

**ALSO AVAILABLE:** Slotted lines, terminations signal generators, tubes, adapters, attenuators "E" sections; rotating joints, wavemeters, tube mounts, magnets, thermistor mounts, etc.

**10 CENTIMETER:** All test components; rigid coaxial lines; waveguides; tubes; antennas.

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| 2000 | UG86U connectors, pressurized, gold plated |
| 13500 | Chassis connectors 5 pin, Monowatt AN3102-14S-5P |
| 18300 | Chassis connectors 4 pin, Amphenol 14S-2P |
| 1000 | Westinghouse type NX-35, 0-350 volts, dc meters, F.S. 0.1 ma, 3½" bakelite case |
| 1000 | Marion sealed meters, type HM3, 100-0-100 ma, F.S. 1-0-1 ma, 3½" bakelite case |
| 1000 | Copper oxide rectifiers, 40 ma 150 volts |
| 5000 | Copper oxide rectifiers, 1 ma 45 volts |
| 1200 | UG245U connectors |
| 35000 | PL259 or Amphenol 83-1SP UHF Connectors |
| 2000 | Sprague Vitamin Q Capacitors, 2 x .075, 8000 WVDC |
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Two G.E. model SQ sets new in original portable carrying cases 500 lbs. 90-130 V. 60 Cycle A.C., 320 Watts. Choice A, B or P.P.I. Presentation 300 yards min. range, max. 3, 15, 45 miles! 10 cm. Ideal for schools, laboratories, small boats. Inquiries invited.

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**SCR-517-A.** SURFACE SEARCH 4, 20 and 30 mile ranges; Raytheon, 250 KW peak power input to 2J27 ma netron. Complete set including: spare parts, tubes, wave guides and fittings.
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Discounts on Lots

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3J31 (1cm.) .....$20.00
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2J32 (10cm.) ..... 25.00
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2K25-723AB ..... 7.75
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An APG 5-frequency: 2350 to 2700 Mc. pwr. out, ½KW, comes with lighthouse and TR tubes. Dim: 12"x24".....$110.00

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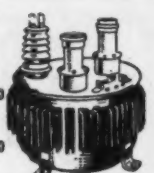

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Utah Blocking oscillator transformer, freq. limits: 790 to 810 CPS, 3 windings, turn ratio- 1:1:1:. Dimensions. 1 13/16"x1 ⅝" 19/32" ..... .75

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| 3.44 mmf | 56 mmf | 82 mmf |
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DYNAMIC OR CARBON MICROPHONE OR LINE INPT: Output PP class "B" GRIDS. Noise Level down—55DB. INCLUDES INPT TRANSF, 1st AUDIO to PPGrids MODULATOR TUBES. 6V6 sidetone adj Audio osc AMP & Hdphone monitoring jack. WT 5LBS. DIM 7-½L 3½W 5"H. minus tubes & pwr supply. "TAB" SPECIAL ..... **$4.95**
WITH TWO 6V6 & 6SJ7..... 7.49

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50-100-200-500 microamps. High Resistance Voltmeters Vacuum Thermo-Couple Meters 3½" & 4½" Round & Rectangular

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Surplus BC-1211 and BC-1212 Television Cameras and Transmitters from Army Guided Missile Program; see I.R.E. June 1946.

Surplus 709B RCA Television Sweep Generators. Just a few left at $550.

Surplus Selsyn Generators, Focus Coils, Barometers, Fractional HP Motors, Polaroid Filters, AC Voltmeters, Tube Testers, Ferris Generators.

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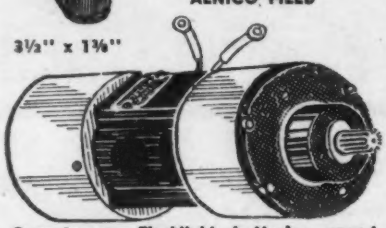
**TELECHRON MOTOR**
1 R.P.M. or 2 R.P.M.
**3.85** LIMITED QUANTITY
**REVERSIBLE GEARED MOTOR**
**ALNICO FIELD**

3½" x 1⅜"



Operates on Flashlight batteries, speed depending on the voltage. Fairly strong on 6 volts, full power and speed on 27 volts. Designed to be used in bombsights, automatic pilots, etc. 250 RPM. A bargain at..... **$5.00**

**HAYDON SYNCHRONOUS TIMING MOTOR**

to operate switches, etc. can be had either 1 Rev. per hour or 1 Rev. per minute at this SPECIAL PRICE **$3.85**

Many other speeds available at $4.95

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Brand new. Built by Allis Chalmers to rigid specifications of the U. S. Navy.

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| P.F. .80 | Cycles 60 |
| Volts input 115. D.C. | Volts output 120. A.C. |
| Amps. input 14 | Amps. output 10.4 |

Length 26"; width 12⅞"; height 13". Compound accumulative A.C. and D.C. fields. Centrifugal starter. Splashproof covered, frequency adjustable to load, plus or minus five cycles.

**Price $87.50**

Identical machine, but 230 volts D.C. input
**$125.00**

*Prices f.o.b. Tuckahoe, New York*
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**One general radio vacuum tube bridge model 516D, with complete set of socket adapters.**

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# METERS

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***Portable D.C. Voltmeter — 0-3/15/150 Volts — Triple Range.***

Used as a reference standard. Accuracy unaffected by wide changes in temperature.

Accuracy: ¼ of 1%. Knife edge pointer—mirror scale.
Scale length: 5.18". With genuine leather case.
List: $117.33.

**Your Cost $57.50**

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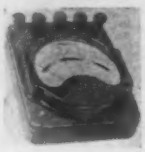

***Westinghouse PX-14***

A rugged instrument of medium accuracy. Magnetically shielded, bakelite case. Mirror Scale. Accuracy ±1%. Scale Length: 3.2". Size: 5-¼" x 4-¼" x 1-¾".

List Price $46.00

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Portable D.C. Voltmeter. 0-15 Volts—100 Ohms per Volt, Accuracy: ½ of 1%. Mirrored scale—5.18" long. Knife edge pointer. Dimensions: 6"x6"x4".

**Your Cost $17.50**

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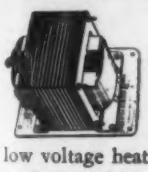

Made by General Electric. Heavy duty stepdown transformer, with considerable overdesign. Ideal for rectifier applications, low voltage heating, general laboratory use, etc. Open frame type.

Input: 115 Volts—60 Cycles
Output: 15 Volts (at full load)
Capacity: 180 V.A.
Size: 3-½" x 3-½" x 4".

**Your Cost $3.75**

**Quantity prices available**

### AMPERES A. C.

0-3 Amps 3" Rd. Westinghouse NA 35 (scale marked 0-120) ..... $3.50
0-5 Amps. 4" Rd. Weston 642 (surface metal case) ..... 7.95
0-5 Amps. 4" Sq. Triplett #431 (flush bakelite case. Scale: 0-150/300 V.)... 2.95

### MICROAMPERES D. C.

0-100 Microamps. Res: 100 Ohms—3" Rd. Westinghouse NX-35 ..... $7.95
(Ideal for pyrometry & Photo-electric work)
0-150 Microamps. Res: 500 Ohms—2" Rd. G. E. DW-51 or NX-33..... $3.75
840-0-840 Microamps (blank scale) Weston 643—4" round—metal case..... $4.50

### MILLIAMPERES D. C.

0-1 Mills—3" Rd. G. E. DO-53..... $4.75
0-1 Mills—3" Rd. Weston 301 ..... 6.75
0-1 Mills—3" Rd. Weston 301 scale: 0-1.5 KV ..... 5.75
0-1 Mills—3" Rd. Marion (special scale) 3.25
0-1 Mills—2" Rd. G. E. DW-41 (special scale) ..... 1.95
0-5 Mills—2" Rd. Dejur S-210 ..... 2.15
0-15 Mills—2" Rd. Weston 506 ..... 3.25
0-500 Mills—2" Rd. G. E. AW-41.... 2.50
1-0-1 Mills—3" Rd. Western Electric Surface (scale 100-0-100) ..... 1.35

### AMPERES D. C.

0-1 Amp. 3" Rd. Weston 301..... $5.95
0.1.5 Amps—4" sq. Triplett #421.... 2.95
0-3 Amps 4" sq. Triplett #421..... 2.95
0-10 Amps—3" Rd. Simpson #25.... 4.95
30-0-30 Amps 3" Rd. Simpson #25.. 4.95
0-80 Amps—2" Rd. Weston #506 (charging Amp caption) (with ext. 50 MV shunt) 3.25
0-300 Amps 3" Rd. Roller-Smith Type TD (with ext. 50 MV shunt)..... 4.95
0-300 Amp. same as above (without shunt) 2.50
0-300 Amp. 4" Rd. Weston 643 (flush metal case) Black scale—with ext. shunt.. 8.50
0-300 Amp. same as above (without shunt) 6.00

### VOLTS D. C.

0-10 Volts 3" Rd. ElectroTech ..... $3.75
0-20 Volts 3" Rd. Weston 506-1000 Ohms/V ..... 3.50
0-50 Volts 4" Rd. Weston NX-37 200 Ohms/V ..... 6.00
0-150 Volts 3" Rd. G. E. D-41..... 4.75
0-150 Volts 3" Rd. Weston 301-200 Ohms/V. (black scale)..... 4.95
0-150 Volts 4" Rd. Weston 643 (flush metal case—black scale) ..... 6.75

### VOLTS A. C.

0-15 Volts—3" Rd. G. E. AO-22 (black scale) ..... $2.95
0-75 Volts—4" Weston 642 (surface mtg) 7.25
0-150 Volts—3" Sq. or Rd. Simpson 57 or 55 ..... 6.00
0-150 Volts—2" Rd. Westh. NA-33... 2.95
0-250 Volts—4" Rd. Triplett #534-B (surface mtg—bakelite) ..... 4.50
0-300 Volts—4" Sq. Triplett #431 Scale: 0-300/600 V. ..... 4.50
0-300 Volts—4" Weston 642 (surface metal case) ..... 9.00

***All Items Listed In This Ad Are New, Unless Otherwise Specified.***

### WESTON MODEL 785 INDUSTRIAL CIRCUIT TESTER

***For Industrial, Labs, Shops, etc., 27 Practical Ranges***

This compact sturdy instrument provides all the ranges necessary for the measurements of voltages, currents and resistances in all types of electrical equipment, signal systems, electronic maintenance and production testing.

Ranges of Measurements:
D.C Voltage: 10 M.V. to 1000 Volts
A.C. Voltage: 0.1 to 750 Volts
A.C. Current: *10 M.A. to 10 Amps.*
D.C. Current: 0.5 Microamps to 10 Amps.
Resistance: 0.5 Ohms to 30 Megohms
List: $138.12

**Your Cost $73.50**

### WESTON MODEL 269 FAN SHAPED METER

One of the Weston popular fan shaped line. Exceptionally long scale for size of instrument. Accuracy—within 1%. Scale length—4". Spade pointer. Here is a good movement for special purpose instruments. Comes with blank scale with arc drawn in. Ready for plotting calibration points. Can be used to make up any range of volts, amps, MA., etc.

Full scale deflection—5 M.A.—40 M.V.
List $29.83

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### • BODINE MOTOR

A small but rugged built-in spur gear reducer motor. Three wire reversible, condenser start. Type KC1-22. 115 volts — 60 cycles — 3.7 R.P.M. 7.5 watts—85 inch ounce torque.

**Your Cost $7.50**

### G.E. Synchronous 1 RPM Motor

General Electric Synchronous Inductor Motor (Heavy Duty Timing Motor) Model 5SMY20J. 115 volts—60 cycles—1 R.P.M. Three wire reversible, condenser start. 1 lb. inch torque. Size: 3⅛" rd x 2¼" deep.

**Your Cost $4.95**

### SPECIAL METERS

0-3 Amps. R. F. Weston 425..... $5.95
0-15 Amps. R. F. Weston 507..... 3.50
Resistance Thermometer 30° F. to 230° F. with res. bulb. Weston #727..... 4.95
Weston 637 Freq. Meter. Aircraft case 3½". Range: 350-450 Cycles, complete....4.95

# POWERTRON Electrical Equipment Co.

**SURPLUS DIVISION: ELECTRO-TECH EQUIPMENT CO.**

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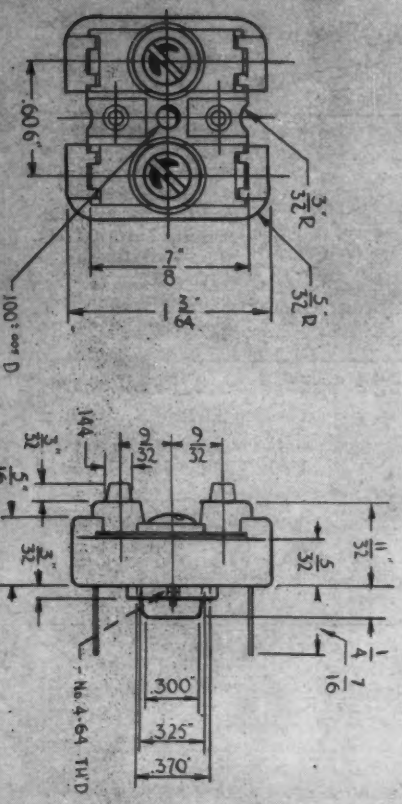
# NEW

# BETTER




Range A 20 to 75 μμfds
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K-TRAN

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AUGUST • 1947

# electronics

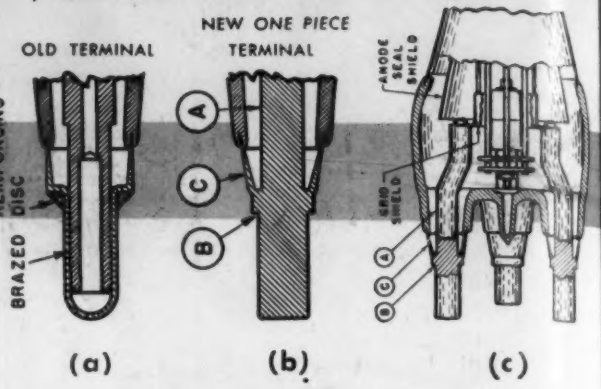
A McGRAW-HILL PUBLICATION

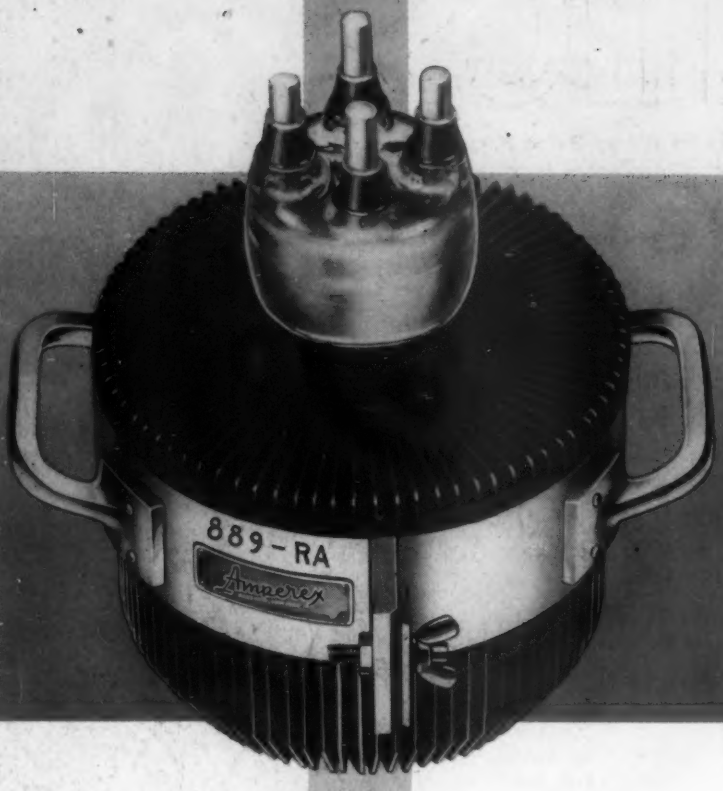
## Coloring Gems by X-Ray

(See Page 138)

BEFORE AFTER

# the **LITTLE** differences




There may be little visible physical difference betwee
good violin and a *great* violin. But, in their respect
performances, these almost invisible differenc
may make *all* the difference. Similarly, while
transmitting tubes may look alike and be designed
serve the same purpose, the little "extras" are
things that give outstanding distinction to Amperex tube

For example, one of these "differences" is the o
piece contact pin, grid and filament support used
the Amperex 889R-A. Heretofore, the pin support a
seal were a brazed assembly (a). Now, they are a
unit, made of pure, oxygen-free copper which is n
magnetic, and has a very low DC resistance and hi
conductivity. A strong conical form replaces the le
desirable cylindrical form at the seal, and the lack
brazing eliminates not only the weaker mechanical are
but also its detrimental effects on the copper and th
glass seal (b).

This new Amperex structure is stronger . . . muc
*stronger!* Where the old pins could be distorted b
side pressure, the new ones resist that pressure up to th
breaking point of the glass. Not only have we adde
strength where it is needed but the one-piece design ha
enabled us to relocate and redesign the anode and gri
shields (c). This has reduced glass heating and resultan
punctures. Laboratory tests also indicate a remarkabl
freedom from grid-filament shorts caused by therma
fatigue. Little differences, yes!—but they make th
Amperex 889R-A *the tube to use when you re-tube*

# make the **BIG** difference

***re-tube with Amperex***

**AMPEREX ELECTRONIC CORPORATION**

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# electronics

A McGRAW-HILL PUBLICATION

## AUGUST • 1947


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